REVISED DRAFT REPORT

COMPARATIVE ANALYSIS OF ALTERNATIVES TECHNICAL MEMORANDUM - ASHLAND/NORTHERN STATES POWER LAKEFRONT SUPERFUND SITE

Prepared for

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Table of Contents

Table of Contents

TABLES

FIGURES

ATTACHMENTS

1.0 Introduction

As required by the Statement of Work (SOW) appending Administrative Order on Consent CERCLA Docket No. V-W-04-C-764 for the Ashland/Northern States Power Lakefront Superfund Site (Site) this document provides a description of remedial alternatives and process options that could be applied to contaminated soil, groundwater and sediment at the Site to reduce the toxicity, mobility or volume of contaminants in these media. These options vary by types of treatment, the amount of contaminated material treated and the manner in which long-term treatment residuals are managed. The options include the statutorily required "no-action" alternative as well as other remedial alternatives which were retained from the Alternatives Screening Technical Memorandum (URS 2007) following USEPA review and comment.

1.1 Background

The Site consists of property owned by Northern States Power Company – Wisconsin (NSPW, a Wisconsin corporation doing business as Xcel Energy, which is a subsidiary of Xcel Energy Inc.), a portion of Kreher Park[1], and sediments in Chequamegon Bay of Lake Superior which is an offshore area adjacent to Kreher Park. The Site is located in Section 33, Township 48 North, Range 4 West in Ashland County, Wisconsin, as shown on Figure 1-1. Existing site features showing the boundary of the site are shown on Figure 1-2.

The NSPW facility is located at 301 Lake Shore Drive East in Ashland, Wisconsin. The facility lies approximately 1,000 feet southeast of the shore of Chequamegon Bay of Lake Superior. The NSPW property is occupied by a small office building and parking lot fronting on Lake Shore Drive, and a larger vehicle maintenance building and parking lot area located south of St. Claire Street between Prentice Avenue and 3rd Avenue East. There is also a gravel-covered parking and storage yard area north of St. Claire Street between 3rd Avenue East and Prentice Avenue, and a second gravel-covered storage yard at the northeast corner of St. Claire Street and Prentice Avenue. A large microwave tower is located on the north end of the storage yard. The office building and vehicle maintenance building are separated by an alley. The area occupied by the buildings and parking lots is relatively flat, at an elevation of approximately 640 feet above mean sea level (MSL). Surface water drainage from the NSPW property is to the north. Residences bound the site east of the office building and the gravel-covered parking area. Our Lady of the Lake Church and School is located immediately west of Third Avenue East. Private homes are located immediately east of Prentice Avenue. To the northwest, the site slopes abruptly to the

[1] Reference to this portion of the Site as Kreher Park developed colloquially over the course of this project. Kreher Park consists of a swimming beach, a boat landing, an RV park and adjoining open space east of Prentice Avenue, lying to the east of the study area of the Site. For purposes of this document and to be consistent with past reports referenced, the portion of the Site to the west of Prentice Avenue, east of Ellis Avenue and north of the NSPW property is referred to as the "Kreher Park Area" or simply Kreher Park.

Canadian National (formerly known as Wisconsin Central Limited) Railroad property at a bluff that marks the former Lake Superior shoreline, and then to the City of Ashland's Kreher Park, on the shore of Chequamegon Bay.

Based on current data, the impacted area of Kreher Park consists of a flat terrace adjacent to the Chequamegon Bay shoreline. The surface elevation of the park varies approximately 10 feet, from 601 feet above MSL, to about 610 feet above MSL at the base of the bluff overlooking the park. The bluff rises to an elevation of about 640 feet above MSL, which corresponds to the approximate elevation of the NSPW property. The lake elevation fluctuates about two feet, from 601 to 603 feet above MSL. At the present time, the park area is predominantly grass covered. A gravel overflow parking area for the Ashland Marina occupies the west end of the property, while a miniature golf facility formerly occupied the east end of the site. The City of Ashland former waste water treatment plant (WWTP) and associated structures front the shoreline on the north side of the property. The impacted area of Kreher Park occupies approximately 13 acres and is bounded by Prentice Avenue and a jetty extension of Prentice Avenue to the east, the Canadian National Railroad to the south, Ellis Avenue and the marina extension of Ellis Avenue to the west, and Chequamegon Bay to the north.

The offshore area with impacted sediments is located in a small bay created by the Prentice Avenue jetty and marina extensions previously described. For the most part, contaminated sediments are confined within this small bay by the northern edge of the line between the Prentice Avenue jetty and the marina extension. The affected sediments consist of lake bottom sand and silts, and are mixed with wood debris likely originating from former log rafting lumbering operations. The wood debris layer is up to seven feet thick in areas, with an average thickness of nine inches. Wood debris overlays approximately 95% of the sediment that is impacted. Based on current data, the entire area of impacted sediments encompasses approximately sixteen acres based upon a Preliminary Remediation Goal (PRG) for sediment of 9.5 µg PAH /g @0.415% OC.

1.2 Nature and Extent

Site characterization began in 1989 when apparent contamination was discovered at Kreher Park. The primary contaminants at the Site are derived from tar compounds[2], including volatile organic compounds (VOCs) and polycyclic aromatic hydrocarbons (PAHs). Soils, groundwater, and offshore sediments have been impacted. The predominant sources of contamination at the Site consist of discrete free-phase hydrocarbons (free-product) derived from the tars that is present as a non-aqueous phase liquid (NAPL) at the following locations:

1. In the filled ravine on the NSPW property;
2. At areas at Kreher Park including the former "seep" area and former coal tar dump area;

[2] The term "tar" is used generically in this document to refer to a suite of VOC and PAH compounds the sources of which are the former MGP and other lakefront industrial operations including wood treatment activities.

3. In the offshore sediments; and
4. In the upper elevations of the deep Copper Falls aquifer.

The upper bluff/filled ravine has a free-product mass at the base of the ravine located south of St. Claire St. below the NSPW service center building. Part of the building includes an older section incorporating the former manufactured gas plant. The free-product is found at the base of the ravine varying in depth from 15 to 20 feet. A perched water table has formed within the filled ravine within four to six feet of the ground surface. This is part of the regional water table that extends across the area within the Miller Creek Formation, a low permeability silty-clay/clayey silt that forms the surficial geologic unit underlying the fills in the Ashland area. Soil and groundwater in the filled ravine are contaminated largely by contact/proximity with the free-product mass. The fill is variable consisting of typical MGP wastes including cinders, debris, and other locally derived detritus.

Within the filled ravine, migration in the down gradient direction toward Kreher Park occurred through both the fill as well as a 12-inch clay tile that extended along the base of the ravine to its mouth. This discharge was eliminated in 2002 with the installation of an interception well (EW-4) at the mouth of the former ravine. Groundwater extracted from the filled ravine is conveyed to the existing tar removal system for treatment prior to discharge to the sanitary sewer

Although the lateral extent of the free-product zone is limited, contaminated soil and groundwater conditions are widespread across the entire Park area. Free-product is present at the seep area and in the former coal tar dump area north of the mouth of the filled ravine at Kreher Park. This material is found at the base of the fill/wood waste layer which underlies the entire Park. In the seep area, contaminated soil above the wood waste layer was removed in 2002 and replaced with clean fill. In the former coal tar dump area, contaminated soil was encountered beneath several feet of clean fill overlying the wood waste layer. Elsewhere in Kreher Park, contaminants were encountered in the wood waste layer beneath several feet of clean surficial soil; oily sheen was observed in several test pits during the test pit investigation in Kreher Park when the underlying wood waste was encountered.

A free-product mass is present underlying the Miller Creek Formation in the same area of the NSPW service center. This material is found within the upper reaches of the Copper Falls aquifer, a sandy, coarse grained unit. Free-product extends from depths of approximately 30 to 70 feet. The greatest thickness of free product is present directly south of St. Claire Street within the main access drive of the NSPW service center. It thins in all directions from this area. Since 2000, NSPW has maintained a free-product recovery system consisting of three extraction wells which have removed over 8,000 gallons of free-product/water emulsification (approximately 10% oil/tar and 90% water from the aquifer.

North of the alley behind the service center, the Miller Creek Formation increases in plasticity creating an aquitard to the Copper Falls aquifer. Vertical gradients in the Copper Falls aquifer south of the alley are downward, indicating this is a zone of recharge. North of the alley, vertical gradients at nested wells screened in the Copper Falls aquifer indicate strong upward flow.

These gradients increase in magnitude with both depth and distance toward Chequamegon Bay. Wells screened in the aquifer north of the bluff face forming the boundary between Kreher Park and the NSPW property are flowing (artesian) wells. Additionally, the aquitard thickens toward the shoreline. This creates an apparent convergent flow condition beneath the center of Kreher Park near MW-2B(NET). Flow in the upper Copper Falls aquifer in this area is potentially restricted because of the configuration of the Miller Creek Formation, which thickens to the north toward the shoreline. Upward vertical discharge through the Miller Creek occurs as shown by the artesian wells at the Park. However, the same condition indicates that the volume of discharge is low due to the low permeability of the aquitard.

Free-product is also present in sediments in the offshore zone along the Kreher Park shoreline, mainly at the sand/wood waste interface (historic lakebed). The greatest mass of material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore. Free-product is found at depths up to four feet below the sediment/water interface in this zone. A separate free product area is found at depths up to 10 feet between the former WWTP and the boat launch.

Section 4.0 in the RI provides specific detail on the distribution of specific contaminants

1.3 Summary of Site Risks

1.3.1 Current and Future Site Use

Current and future uses of the Site include recreational users/visitors, residential (in established residential areas on top of bluff near Xcel Energy office), fishers (both recreational and potentially subsistence), and construction, maintenance and industrial workers. Trespassers are also likely under current conditions in the abandoned WWTP area. Future use of the Kreher Park portion of the Site does not include a residential scenario.

1.3.2 Risks to Human Health

The results of the HHRA indicate that seven exposure pathways result in estimated risks that exceed USEPA's target risk levels (an incremental cancer risk [CR] of 10^{-4} to 10^{-6} and a hazard index [HI] ≤ 1) and eight exposure pathways result in estimated risks that are either equivalent to or exceed the Wisconsin Department of Natural Resources' (WDNR's) threshold of (i.e., CR $\leq 1\times10^{-5}$ and HI] ≤ 1). These exceedances are indicated below.

Exceeds USEPA Risk Range ($\geq 1\times10^{-4}$)	**Exceeds Wisconsin Threshold ($\geq 1\times10^{-5}$)**
Residents (Soil[0-3 feet and all soil depths] - Cancer)	Residents (Soil[0-3 feet and all soil depths] - Cancer)
	Residential Child (Soil – Noncancer)
Construction Worker (Soil [0-10 feet bgs]/Groundwater)	Construction Worker (Soil [0-10 feet bgs]/Groundwater)
Construction Worker (Trench Air)	Construction Worker (Trench Air)
Adult Swimmer (Surface Water with Oil Slicks)	Adult Swimmer (Surface Water)

Adult Wader (Surface Water with Oil Slicks)	Adult Wader (Surface Water with Oil Slicks/Sediment)
Industrial Worker (Indoor Air)	Industrial Worker (Indoor Air)
Subsistence Fisher (Biota)	Subsistence Fisher (Biota)

These include estimates for the reasonable maximum exposure (RME) scenarios for potential cancer risks and non-cancer risks. These conclusions are based on assumed exposures to soil in the filled ravine area (for residential receptors) and the filled ravine, upper bluff and Kreher Park area (for construction worker receptors), and to indoor air samples collected at NSPW Service Center. Carcinogenic risks based on central tendency evaluation (CTE) scenarios indicate that only the residential receptor exposure to soil (all soil depths to 10 feet bgs) are estimated to be at a CR of 1×10^{-4}, the upper-end of the USEPA target risk range or greater than the WDNR threshold. Noncarcinogenic risks for the residential receptor (for soil depths 0-1 foot and 0-3 foot bgs) and risks associated with the construction scenario are within acceptable levels. However, residential receptor exposure to subsurface soil is not expected, given the current and potential future land use of the Site. For this Site, residential risks associated with exposures to surface soil (0 to 1 foot bgs) are within the target risk ranges.

Although the results of the HHRA indicate risks for the construction workers under the RME conditions exceed USEPA's target risk levels, the assumptions used to estimate risks to this receptor were conservative and assumed the worst case. Given both the current and future land use of the Site, it is unlikely that construction workers would be exposed to soil in the filled ravine and Upper Bluff. The most likely scenario for the future construction worker is exposure to soil within 0 to 4 feet below ground surface (bgs) in Kreher Park (a typical depth for the installation of underground utility corridors), as most activities associated with the implementation of the future land use would be associated with regrading, landscaping, and road or parking lot construction. Therefore, risks to this receptor population are most likely overstated in this HHRA.

An HI of 3 was calculated for the general industrial worker exposure to indoor air pathway under the RME conditions. This risk level is likely to be an overestimate because:

- It was estimated using the maximum detected concentrations as the concentrations at points of exposure.
- It was calculated based on USEPA default exposure parameters for the industrial /commercial workers (i.e., an individual works at the Site for 8 hours per day, 5 days per week, 50 weeks per year for a total of 25 years). The NSPW Service Center is used as a warehouse; there is an office space inside the building, but used only on a part-time basis.

Cancer risks to subsistence fisher (finfish) are equivalent to the upper-end of the USEPA target risk range, but greater than the WDNR threshold of a CR of 1×10^{-5}. Noncarcinogenic risk is within acceptable limits for both USEPA and WDNR.

Risks to recreational children (surface soil) are equivalent to the WDNR risk threshold. However, risks to adolescent and adult receptors exposed to surface soil are below the USEPA acceptable risk range and below the WDNR risk threshold.

Risks to waders and swimmers (sediments), industrial workers (surface soil), and maintenance workers (surface soil) are all within USEPA's target risk range of 10^{-4} to 10^{-6} for lifetime cancer risk and a target HI of less than or equal to 1 for non-cancer risk and are less than the WDPH threshold of 1×10^{-5} for lifetime cancer risk and a target HI of less than or equal to 1 for non-cancer risk.

At the request of the WDHFS, risks were also estimated for construction workers exposed to "oily materials" in groundwater via dermal contact and swimmers and waders who may be exposed to oil slicks in surface water via ingestion and dermal contact. Because no media-specific concentrations are available for either scenario, risks were estimated using analytical data collected from the product stream from the active free product recovery system for the Copper Falls aquifer or chemical-specific solubility values detected in the DNAPL sample. Risks to construction workers exposed to "oily material" in groundwater and adult swimmers and waders exposed to "oil slicks" in surface water is greater than both the USEPA upper risk range (CR 1×10^{-4} and HI of 1) and than WDNR threshold (CR 1×10^{-5} and HI of 1). However, it is important to note that there is much uncertainty associated with estimating risks to oily material in groundwater or oil slicks in surface water. The primary uncertainties are associated with the lack of established methodology for estimating this exposure pathway.

1.3.3 Risks to Ecological Receptors

The BERA concluded that the potential for adverse effects to ecological receptors other than benthic macroinvertebrates was not sufficient to result in significant adverse alterations to populations and communities of these ecological receptors. Unacceptable impacts to the benthic macroinvertebrate community in aquatic portions of the Site are possible. Two lines of evidence, bulk sediment chemistry and sediment toxicity testing, indicated that the probability of impairment at the community level was likely.

However, the fact that hydrocarbons are sporadically released as sheens from Site sediment during some high energy meteorological events or when disturbed indicates the potential for impact to the benthic community that may not have necessarily been fully measured by the studies conducted to support the RI. While there is no evidence that effects from these releases will lead to impairment of populations and communities of these receptors inhabiting the waters of Chequamegon Bay, the presence of this continuing source degrades the functioning of a healthy aquatic community in the Site area.

In addition, if normal lakefront activities, i.e., wading, boating etc., were not presently prohibited, the disturbance of sediments and concomitant release of subsurface COPCS would increase. This potentially could lead to greater impacts than were measured during these RI/FS studies.

1.4 Document Purpose

This document presents a comparative analysis of remedial alternatives that could be implemented to manage impacted environmental media at the Site. In accordance with USEPA guidance, remedial alternatives that have been retained from the Alternatives Screening will be evaluated against a set of nine evaluation criteria, and a comparative analysis of all options using the same nine criteria as a basis for comparison. These nine criteria can be divided into three categories: threshold criteria, primary balancing criteria and modifying criteria.

Threshold criteria, which relate to statutory requirements that each alternative must satisfy in order to be eligible for selection, include:

- Overall protection of human health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs).

The *primary balancing criteria*, which are the technical criteria upon which the detailed analysis is primarily based, include:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

The third group, the *modifying criteria*, includes:

- State/support agency acceptance
- Community acceptance.

These last two criteria are typically formally evaluated following the public comment period, although they can be factored into the identification of the preferred alternative to the extent practicable.

The nine evaluation criteria will be applied to the assembled remedial alternatives to ensure that the selected remedial alternative will:

- protect human health and the environment and meet remedial action objectives;
- comply with or include a waiver of ARARs;
- be cost-effective;
- utilize permanent solutions and alternative treatment technologies, or resource recovery technologies, to the maximum extent practicable; and
- address the statutory preference for treatment as a principal element.

In addition, each alternative will provide:

- a description of the alternative that outlines the waste management strategy involved and identifies the key ARARs associated with each alternative, and
- a discussion of the individual criterion assessment.

If there is no direct input on state (or support agency) acceptance and community acceptance, USEPA will address these criteria.

Once each alternative is compared to the nine criteria, a comparative analysis between the remedial alternatives is performed using the evaluation criteria as a basis of comparison. Using this comparative analysis, USEPA will identify and select the preferred alternative.

1.5 Document Organization

This document is organized in the following manner:

Section 1 – Introduction
Section 2 – Remedial Alternatives for Soil
Section 3 – Remedial Alternatives for Groundwater
Section 4 – Remedial Alternatives for Sediment
Section 5 – Summary and Conclusions
Section 6 – References

2.0 Remedial Alternatives for Soil

This section on Comparative Analysis of Soil Alternatives is organized as follows:

2.1 Remedial Action Objectives for Soil

The general goal of RAOs is to protect human health and environmental receptors at risk due to unacceptable concentrations of constituents of potential concern (COPCs) at the Site. These objectives are subject to the criteria evaluated in the FS. As described in the RAO Tech Memo (URS 2007) preliminary remedial action objectives for soil are as follows:

- Protect human health by reducing or eliminating exposure (ingestion/direct contact/inhalation) to soil having COPCs representing an excess cancer risk greater than 10^{-6} as a point of departure (with cumulative excess cancer risks not exceeding 10^{-5}) and a hazard index (HI) greater than 1 for reasonably anticipated future land use scenarios.
- Ensure future beneficial commercial/industrial use of the Site and recreational use of Kreher Park.
- Protect populations of ecological receptors or individuals of protected species by eliminating exposure (direct contact with or incidental ingestion of soils or prey) to soil with levels of COPCs that would pose an unacceptable risk.
- Conduct free product removal whenever it is necessary to halt or contain the discharge of a hazardous substance or to minimize the harmful effects of the discharge to the air, land or water.
- Protect the environment by minimizing/eliminating the migration of contaminants in the soil to groundwater or to surrounding surface water bodies.

2.2 Potential Remedial Technologies for Soil

This section presents a description of remedial technologies retained for additional evaluation based on the results of the ASTM (revised May 9, 2007). The following remedial technologies for soil were retained for screening, and are described in detail in Section 2.3.

1. No Action
2. Containment
3. Removal and Off site Disposal
4. Removal and On site Disposal
5. On site and Off site Thermal Treatment

6. Ex-situ Soil Washing

As noted in the Alternatives Screening Technical Memorandum (URS 2007), the following technologies for soil remediation were also evaluated for groundwater.

- Institutional Controls
- Monitored Natural Attenuation
- Containment using Engineered Surface and Vertical Barriers;
- In-situ Treatment using Soil Vapor Extraction
- In-situ Treatment by Chemical Oxidation
- In-situ Treatment by Thermal Desorption

Institutional controls and monitored natural attenuation were not retained for screening as stand alone remedial responses; both technologies were evaluated as elements of other active remedial responses for soil and groundwater. Containment of contaminated soil encountered at the Site will be implemented with existing barriers that meet the ARAR's, or the construction of engineered surface barriers to eliminate the direct contact exposure pathway. Surface barriers could also be designed and constructed to restrict or minimize infiltration to reduce contamination leaching into groundwater from the unsaturated zone. Consequently surface barriers were evaluated as a stand alone remedial response for soil, and in combination with other soil and groundwater remedial responses. Containment using engineered surface and vertical barriers were also evaluated as a potential remedial technology for groundwater. Additionally, in-situ treatment by soil vapor extraction (SVE) was evaluated with other in-situ (chemical oxidation and thermal treatment) groundwater remedial technologies. Potential remedial alternatives for groundwater are described in Section 3.0 below.

2.3 Development of Potential Remedial Alternatives for Soil

Conceptual designs for potential remedial alternatives for soil retained for screening and evaluated in this report are as follows. Remedial alternatives presented in this report are summarized in Table 2-1, included at the end of this Section.

2.3.1 Alternative S1 - No Action

The National Contingency Plan (NCP) at Title 40 Code of Federal Regulations (40 CFR §300.430(e)(6)) provides that the no-action alternative should be considered at every site. Implementation of no further action consists of leaving contaminated soil in place; no engineering, maintenance, or monitoring will be required. The "no action" alternative for soil was retained as required by the NCP as a basis for comparing the other alternatives.

2.3.2 Alternative S2 – Containment Using Engineered Surface Barriers

Surface barriers that would prevent direct contact with subsurface soil contamination include the following:

- Asphalt cap;
- Clay cap;
- Multi-layer cap with a minimum two-foot thick clay barrier, drainage layer, soil and vegetated top soil cover; and,
- Multi-layer cap with geomembrane or equivalent (geocomposite fabric layer or GCL).

Key elements of the conceptual design for the use of engineered surface barriers for source areas at the upper bluff area and at Kreher Park are as follows:

1. In the upland area the existing building and asphalt pavement will be repaired, upgraded or replaced to improve the integrity of the barriers on the south side of St. Claire Street.
2. New asphalt pavement on the north side of St. Claire Street (NSPW storage yard) and in Kreher Park (marina parking lot) could be installed as surface barriers for these areas to replace existing gravel surfaces.
3. A RCRA class C or D cap will be placed over the former coal tar dump area. This will be an extension of the fine grained low permeability soil cap installed in the adjacent former seep area (following the removal of contaminated soil) as an interim response in 2002.
4. Existing fill soils covering the remainder of Kreher Park are currently preventing contact with contamination in the underlying wood waste layer. Because no VOC or SVOC contaminants exceeded PRGs is fill soils there is no need to cap the remainder of Kreher Park.
5. The former waste water treatment plant is also preventing contact with the subsurface. In the event that the building is removed, the area will be covered with a clay cap or asphalt pavement.
6. Surface barriers will be periodically inspected and repaired or replaced as needed to ensure they are performing as designed.

Surface barriers would not reduce contaminant mass or toxicity of contaminants remaining in place, but they would prevent direct contact with contaminated soil. However, surface barriers would reduce infiltration minimizing the potential migration of contaminants from the unsaturated zone to the saturated zone. Consequently, surface barriers were evaluated in combination with remedial responses for soil described below, and in combination with groundwater remedial alternatives described in Section 3.0.

2.3.3 Alternative S3 - Removal and Off site Disposal

Removal consists of the excavation of contaminated soil with conventional earth moving equipment. Off site disposal consists of the transportation of excavated material to an off site landfill for disposal. Off site disposal may include the selection of one or more existing landfill facilities for disposal, or alternatively siting and constructing a landfill in the Ashland area in accordance with ch. NR 500, WAC. Off site disposal options will be evaluated in the Feasibility Study, and will depend on the disposal volume of all material from the Site. Off site disposal options are further described in Section 4.3.5.

Following excavation, residual soil and groundwater contamination may remain, which may require natural attenuation and institutional controls for site closure if contaminants remain above RAOs. Both limited and unlimited removal alternatives were retained for evaluation as potential remedial alternatives as described below.

Alternative S3A - Limited Removal and Off site Disposal

Limited removal involves the excavation of material from areas with the highest levels of contamination. At the upper bluff area, this will require the removal of material from the two areas in the filled ravine. The first and largest area is the former gas holder area on the south side of St. Claire Street where NAPL has been encountered. The second and smaller area is at the base of the filled ravine on the north side of St. Claire Street; NAPL was encountered at the base of the ravine at this location in and around a former clay pipe encountered during a 2001 site investigation. The lateral extent of these excavations are shown on Figure 2-1. Key elements of the conceptual design for limited removal at the upper bluff area are as follows:

1. Demolition of the center section of the NSPW service center for excavation south of St. Claire Street will be required to access contaminated soil beneath the building at the upper bluff area.
2. Removal of existing asphalt pavement in the alley and courtyard area will also be required.
3. All shallow water table wells screened in the fill soil unit will be abandoned prior to excavation. Piezometers screened in the underlying Copper Falls aquifer will be protected during excavation and backfilling activities and remain in place for future use.
4. Removal will be limited to the excavation of soil containing NAPL, and the removal of buried structures (i.e. former gas holders south of St. Claire Street and the clay tile north of St. Claire Street) at the upper bluff area.
5. Removal south of St. Claire Street will include the excavation of unsaturated and saturated zone soils to a depth between 12 and 15 feet for an area approximately 130 feet by 130 feet, yielding between 7,600 to 9,400 cubic yards.
6. Removal north of St. Claire Street will include the excavation of saturated zone soil from the bottom five feet of the filled ravine where the clay tile and NAPL were encountered. At the surface, this excavation area will be approximately 30 feet by 75 wide. An estimated 75 to 150 cubic yards of NAPL contaminated soil will be removed from the base of the filled ravine.
7. Deep excavations, or excavations completed near facility buildings may require shoring to support sidewalls.
8. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the existing on site treatment system prior to discharge to the sanitary sewer.
9. Excavated material will be transported off site for disposal at an existing licensed landfill facility.

10. Site restoration will include backfilling excavated areas with clean fill material and installation of new asphalt pavement as a surface barrier over the excavated area south of St. Claire Street to prevent contact with residual soil contamination. On the north side of St. Claire Street, fill soil (overlying NAPL contaminated soil) will be returned to the excavation, and clean soil will be used as to backfill the excavation to grade. Asphalt pavement will be then be placed over the entire gravel covered storage yard as a surface barrier to prevent exposure to fill material left in place on this side of the street. The existing street will be upgraded as needed to provide a surface barrier for this portion of the filled ravine.

At Kreher Park, limited removal will require the excavation of approximately 4,000 cubic yards of contaminated soil overlying the saturated wood waste layer at the former coal tar dump area. The lateral extent of this excavation is also shown on Figure 2-1. Key elements of the conceptual design for limited removal at Kreher Park are as follows:

1. Site preparation will include clearing and grubbing of small trees and bushes near the south side of the former coal tar dump area.
2. Clean fill soil overlying contaminated soil at the former coal tar area will be removed and used as backfill material following the removal of contaminated soil above the saturated wood waste layer.
3. Removal will include the excavation of unsaturated and saturated zone soils approximately 5 feet thick for an area approximately 280 feet by 130 feet, yielding approximately 4,000 cubic yards.
4. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the on site treatment system prior to discharge to the sanitary sewer.
5. Excavated material will be transported off site for disposal at an existing licensed landfill facility.
6. Site restoration will include backfilling with clean fill material, and installation of a new RCRA Class C or D cap over the excavated area.

Existing fill soils covering the remainder of Kreher Park are currently preventing contact with contamination in the underlying wood waste layer. As described for Alternative S-2 above (Section 2.3.2), new asphalt pavement could be installed in Kreher Park as a surface barrier in the marina parking lot area to replace the existing gravel surface. The former waste water treatment plant is also preventing contact with subsurface materials. In the event that the building is removed, the area will be covered with a clay cap or asphalt pavement. These surface barriers are evaluated as potential groundwater remedial alternatives in Section 3.0.

Alternative S3B - Unlimited Removal and Off site Disposal

Unlimited removal will consist of the removal of all fill material and contaminated soil above RAOs. At the upper bluff area, this will require the excavation of all fill material from the filled ravine. The lateral extent of the filled ravine is shown on Figure 2-2. Key elements of the conceptual design for unlimited removal at the upper bluff area are as follows:

1. Demolition of the center section of the NSPW service center for excavation south of St. Claire Street will be required to access contaminated soil beneath the building at the upper bluff area.
2. Removal of existing asphalt pavement in the alley and courtyard area will also be required.
3. Removal and replacement of the section of St. Claire Street overlying the filled ravine (including underground utility realignment) will also be required.
4. Removal will include the excavation of soil containing NAPL, and the removal of all underground structures (i.e. former gas holders) at the upper bluff area.
5. Removal will include the excavation of approximately 32,500 cubic yards of unsaturated and saturated zone fill material from the filled ravine, including an estimated 15,000 cubic yards of fly ash material from the area on the north side of St. Claire Street.
6. Deep excavations, or excavations completed near facility buildings may require shoring to support sidewalls.
7. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the on site treatment system prior to discharge to the sanitary sewer.
8. Excavated material will be transported off site for disposal at an existing licensed landfill facility. (Fly ash material may be transported to NSPW's fly-ash landfill for disposal.)
9. Site restoration will include backfilling with clean fill material, replacement of St. Claire Street and utilities, and the installation of new asphalt pavement over excavated areas on the north and south side of St. Claire Street as a surface barrier for any residual soil contamination.

At Kreher Park, this will require the removal of the wood waste layer and overlying fill soil between Prentice and Ellis Avenues. The lateral extent of the excavation area is shown on Figure 2-2. Key elements of the conceptual design for unlimited removal at Kreher Park are as follows:

1. Site preparation will include clearing and grubbing small trees and bushes near the south side of the former coal tar dump area.
2. Clean fill soil overlying the wood waste layer will be removed, salvaged and used to backfill the excavated former ravine at the upper bluff area.
3. Removal will include the excavation of the wood waste layer and the overlying fill soil. The estimated volume of fill soil and wood waste material is approximately 223,000 cubic yards.
4. Because the excavation will be completed below lake level, a temporary sheet pile wall will constructed on the north, east, and west sides of the construction area to allow a dry excavation.
5. Groundwater removed from the saturated portion of the excavation and any seepage into the excavation will be collected and treated by an on site treatment system prior to discharge to the sanitary sewer[3].

[3] If sediment removal is selected, on site treatment equipment from sediment de-watering activities will be utilized for the on site treatment of groundwater encountered in the unlimited excavation of Kreher Park.

6. Excavated material will be transported off site for disposal at a new landfill facility sited and constructed for the disposal of this material. If possible, wood suitable for fuel at the Bayfront power plant will be salvaged and used for power generation.

Removal of all fill material in the Kreher Park would likely require the construction of an off site landfill. Unlimited removal will result in significant site disturbance, which may result in temporary or permanent loss of the current use of Kreher Park.[4] Kreher Park could be restored to pre-filling conditions (i.e. wetland area or shallow lakebed), backfilled with clean fill to restore it to present elevations, or backfilled with contaminated sediment. Backfilling with contaminated sediment would require the construction of an onshore confined disposal facility (CDF) for the placement of material removed from the adjacent inlet area. Wisconsin Administration Code Chapter 30 does not prohibit construction of a nearshore CDF and disposal of dredged sediments into a newly constructed CDF. Because contaminated soil will be excavated from the saturated zone encountered below lake level, removal and treatment of contaminated groundwater seeping into the excavation will be required.

2.3.4 Alternative S4 - Removal and On site Disposal

Removal will consist of the excavation of contaminated soil with conventional earth moving equipment. On site disposal consists of the transportation of excavated material to an on site landfill for disposal. Residual soil and groundwater contamination may remain above RAOs, which may require natural attenuation and institutional controls for site closure if contaminants remain above RAOs. Inadequate space is available for on site disposal at the upper bluff area, but adequate space is available at Kreher Park for the construction of an on site disposal cell. The on site disposal cell in Kreher Park could accommodate all or a portion of the material removed from the filled ravine at the upper bluff area previously described for Alternatives S3A (limited removal) and S3B (unlimited removal). It could also accommodate the limited removal of contaminated soil from the former coal tar dump area. Additionally, on site disposal could accommodate the disposal of dredged sediment from the inlet area. On site disposal would need to be completed in combination with containment alternatives for shallow groundwater at Kreher Park described in Section 3.0, and/or in conjunction with sediment containment alternatives described in Section 4.0. Key elements of the conceptual design for limited and unlimited removal of material from the filled ravine at the upper bluff and limited removal of contaminated soil from the former coal tar dump area are described above. The conceptual design for the construction of an on site disposal facility at Kreher Park follows:

1. Site preparation will include clearing and grubbing of small trees and bushes near the south side of the former coal tar dump area.
2. A disposal cell will be constructed at Kreher Park adjacent to the former coal tar dump area for the disposal of material excavated from the upper bluff area. The size of the disposal cell will be approximately one acre for limited excavation, and four acres for

[4] Kreher Park is currently utilized as a recreation area, but it also contains the marina boat storage area, a City street adjacent to the shoreline, and the former waste water treatment building.

unlimited removal at the upper bluff area. Contaminated soil from the former coal tar dump area would also be placed in the disposal cell. A RCRA class C or D cap will then be placed over the disposal cell. This soil remedial alternative could be combined in combination with containment alternatives evaluated for groundwater and sediment in Sections 3.0 and 4.0, respectively.[5].

3. Clean fill soil overlying the wood waste layer at Kreher Park will be removed for the construction of the disposal cell and used to backfill excavated areas. Fill soil outside the foot print of this area will be left in place.
4. Any groundwater seeping into the disposal cell during construction will be collected, temporarily placed in holding tanks, and treated by an on site treatment system prior to discharge to the sanitary sewer[6].
5. Site restoration at the upper bluff will include backfilling with salvaged clean fill material and installation of a RCRA cap or new asphalt pavement over the excavated area south of St. Claire Street, the existing street, and the gravel covered courtyard area on the north side of the street.
6. Long-term operation and maintenance for the disposal cell or CDF will include the groundwater monitoring and periodic inspection and repair of all asphalt and soil caps.

2.3.5 Alternative S5 – Ex-situ Thermal Treatment

Thermal treatment physically separates volatile and some semi-volatile contaminants from excavated soil or sediment by using ambient air, heat, and/or mechanical agitation to volatilize contaminants from soil into a gas stream for further treatment. Thermal treatment is achieved by either low temperature thermal desorption (LTTD), high temperature thermal desorption (HTTD), or incineration. The type of thermal treatment selected will be based on RAOs for VOCs and PAHs in treated soil. Another consideration is the suitability of treated soil as backfill material; soil treated by LTTD will retain pre-treatment physical properties (i.e. organic content) whereas soil treated by HTTD and incineration will not. Soils thermally treated on site can be returned to the excavation as backfill. Clean fill will be needed to replace soils transported off site for treatment and disposal.

LTTD is highly effective for VOCs; PAH compounds can also be treated, but at a reduced effectiveness. HTTD is effective for PAH compounds, but is not as cost effective as LTTD for VOCs. Incineration is effective for both VOCs and PAH compounds, but treating contaminated soil at high temperatures (1,400 to 2,200 ºF) to volatilize and combust organic compounds would require significantly more effort than LTTD or HTTD. An on site mobile incinerator would

[5] A larger disposal cell would be needed for on site disposal of sediment in an on site confined disposal facility (CDF). The on site disposal of an additional 134,000 cubic yards of sediment would require a CDF 8 acres in size with a waste thickness of approximately 13 feet. The on site disposal of an additional 78,000 cubic yards of sediment would require a CDF 6 acres in size with a waste thickness of approximately 12 feet.

[6] If sediment removal is selected, on site treatment equipment from sediment de-watering activities may also be utilized for the on site treatment of groundwater seeping into the excavation during construction.

operate in a similar fashion as HTTD except the kiln would be direct-fired[7] and would cause some COPCs to be destroyed before the vapors reach the secondary combustion chamber. In addition the gas flow rates are higher since the fuel and air combustion gases are included in the gases sent from the kiln to the secondary combustion chamber. Additional soil tests such as sieve analysis, soil fusion temperature, and soil heating value are generally needed to achieve proper incineration. Although mobile incinerators are available, most incineration is achieved at off site facilities due to the substantial amount of equipment involved. Transportation costs, energy costs to sustain high temperatures, and regulatory compliance for incineration would be significantly higher than LTTD and HTTD costs. For this analysis we have assumed that on site treatment will be completed by LTTD or HTTD, and that incineration will be completed at an off site facility.

Alternative S5A - Limited Removal and On site Thermal Treatment

On site thermal treatment will require excavation of contaminated material at the upper bluff area as previously described for the limited removal alternatives described above (Alternatives S-3A and S-4). Excavated soil could be transported off site, but most likely would be treated on site by a mobile unit. Debris must be separated by size from material suitable for thermal treatment and transported off site for disposal. Consequently, wood waste at Kreher Park and fly-ash and cinders in the filled ravine at the upper bluff area must be separated from NAPL contaminated material encountered in these areas. Thermal treatment by LTTD or HTTD will be completed for suitable NAPL contaminated fill material, and contaminated material not suitable for thermal treatment will be transported off site for disposal.. Fill material including fly ash and cinders that is not contaminated with VOC and PAH compounds will be returned to the excavation. Residual soil and groundwater contamination may remain, which may require natural attenuation and institutional controls for site closure if residual contaminants remain above RAOs.

Thermal treatment will be performed on suitable fill material from areas with the highest levels of contamination. This includes the former gas holder area at the upper bluff, the free product in the ravine and contaminated soil encountered above the wood waste layer at Kreher Park. The lateral extent of these excavations are shown on Figure 2-1. Key elements of the conceptual design for ex-situ thermal treatment of material removed from these areas follows:

1. A mobile unit and ancillary equipment will be set up at Kreher Park because inadequate space is available at the upper bluff area.
2. Demolition of the center section of the NSPW service center for excavation south of St. Claire Street will be required to access contaminated soil beneath this building at the upper bluff area.
3. Removal of existing asphalt pavement in the alley and courtyard area will also be required.

[7] Medium and high temperature thermal desorption may also be direct-fired, but at a lower temperature than incineration.

4. All shallow water table wells screened in the fill soil unit will be abandoned prior to excavation. Piezometers screened in the underlying Copper Falls aquifer will be protected during excavation and backfilling activities and remain in place for future use.
5. Removal will include the excavation of soil containing NAPL, and the removal of buried structures (i.e. former gas holders) at the upper bluff area south of St. Claire Street. This area includes the excavation of unsaturated and saturated zone soils to a depth between 12 and 15 feet for an area approximately 130 feet by 130 feet, yielding between 7,600 and 9,400 cubic yards. Also included for removal will be soil containing NAPL in the ravine on the north side of St. Claire Street. This will include the excavation of saturated zone soil from the bottom five feet of the filled ravine where the clay tile and NAPL were encountered. At the surface, this excavation area will be approximately 30 feet by 75 wide. An estimated 75 to 150 cubic yards of NAPL contaminated soil will be removed from the base of the filled ravine.
6. Removal will also include the excavation of unsaturated and saturated zone soils at the former coal tar dump area. This includes approximately 5 feet of contaminated soil in an area approximately 280 feet by 130 feet, yielding approximately 4,000 cubic yards.
7. Deep excavations, or excavations completed near facility buildings may require shoring to support sidewalls.
8. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the on site treatment system prior to discharge to the sanitary sewer.
9. Saturated and unsaturated zone material will be thermally treated to reduce contaminant mass and toxicity and returned to the excavation as back fill. Material unsuitable for thermal treatment will be transported off site for landfill disposal. Fill material not contaminated with VOC and PAH compounds will be returned to the excavation as backfill.
10. Site restoration at the upper bluff area will include the installation of new asphalt pavement as a surface barrier over the excavated area on both sides of St. Claire Street, and new asphalt pavement at the gravel covered courtyard area on the north side of the street. The existing street (inspected for water tightness and sealed or replaced as needed) and new asphalt pavement on the NSPW property will prevent exposure to fill material beneath St. Claire Street and the NSPW storage yard.
11. Site restoration at Kreher Park will include backfilling excavated areas with clean fill material and installation of a new RCRA Class C or D cap over the excavated area.
12. Long-term operation and maintenance of backfilled areas will include groundwater monitoring, cap maintenance including the periodic inspection and repair of all asphalt and soil caps.

Alternative S5B - Limited Removal and Off site Incineration

Incineration will require excavation of contaminated material at the upper bluff area and the former coal tar dump area at Kreher Park as previously described for the other limited removal alternatives (Alternatives S-3A, S-4, and S-5A). Contaminated soil suitable for incineration would be transported off site to a licensed facility for treatment and disposal. Wood waste at Kreher Park and fly-ash and cinders in the filled ravine at the upper bluff area must be separated from contaminated soil selected for incineration. Debris will be separated by size from material suitable for incineration and transported off site for disposal, and fill material not contaminated with VOCs and PAHs will be returned to the excavation as backfill.

As with thermal treatment, incineration will be performed on suitable fill material from areas with the highest levels of contamination. This includes the former gas holder area at the upper bluff, the free product in the ravine and contaminated soil encountered above the wood waste layer at Kreher Park. The lateral extent of these excavations are shown on Figure 2-1. Key elements of the conceptual design for ex-situ thermal treatment of material removed from these areas follows:

1. All contaminated material will be separated from debris and transported off site for incineration and/or off site disposal. Ancillary equipment needed to separate material suitable for incineration will be set up at Kreher Park because inadequate space is available at the upper bluff area.
2. Demolition of the center section of the NSPW service center for excavation south of St. Claire Street will be required to access contaminated soil beneath the building at the upper bluff area.
3. Removal of existing asphalt pavement in the alley and courtyard area will also be required.
4. All shallow water table wells screened in the fill soil unit will be abandoned prior to excavation. Piezometers screened in the underlying Copper Falls aquifer will be protected during excavation and backfilling activities and remain in place for future use.
5. Removal will include the excavation of soil containing NAPL, and the removal of buried structures (i.e. former gas holders) at the upper bluff area south of St. Claire Street. This area includes the excavation of unsaturated and saturated zone soils to a depth between 12 and 15 feet for an area approximately 130 feet by 130 feet, yielding between 7,600 and 9,400 cubic yards. Also included for removal will be soil containing NAPL in the ravine on the north side of St. Claire Street. This will include the excavation of saturated zone soil from the bottom five feet of the filled ravine where the clay tile and NAPL were encountered. At the surface, this excavation area will be approximately 30 feet by 75 wide. An estimated 75 to 150 cubic yards of NAPL contaminated soil will be removed from the base of the filled ravine.
6. Removal will also include the excavation of unsaturated and saturated zone soils at the former coal tar dump area. This includes approximately 5 feet of contaminated soil in an area approximately 280 feet by 130 feet, yielding approximately 4,000 cubic yards.
7. Deep excavations, or excavations completed near facility buildings may require shoring to support sidewalls.
8. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the existing on site treatment system prior to discharge to the sanitary sewer.
9. Saturated and unsaturated zone material will be transported off site for incineration and subsequent off site disposal. Material unsuitable for incineration will be transported off

site for landfill disposal. Fill material not contaminated with VOC and PAH compounds will be returned to the excavation as backfill.

10. Site restoration will include backfilling the excavation with clean fill material and installation of new asphalt pavement as a surface barrier over the excavated area south of St. Claire Street to prevent contact with residual soil contamination. On the north side of St. Claire Street, fill soil (overlying NAPL contaminated soil) will be returned to the excavation, and clean soil will be used as to backfill the excavation to grade. Asphalt pavement will be then be placed over the entire gravel covered storage yard as a surface barrier to prevent exposure to fill material left in place on this side of the street. The existing street will be upgraded, as needed, to provide a surface barrier for this portion of the filled ravine.
11. Long-term operation and maintenance of backfilled areas will include groundwater monitoring, cap maintenance including the periodic inspection and repair of all asphalt caps.

2.3.6 Alternative S6 – Limited Removal and On site Soil Washing

Soil washing is a water-based process for mechanically scrubbing excavated soil to remove contaminants by dissolving or suspending them in the wash solution. Contaminated soil from the saturated and unsaturated zones will be treated by soil washing following removal by excavation. Contaminants are either removed by dissolving or suspending them in a wash solution, or reducing concentrations in smaller volumes of soil by gravity separation. Wastewater used for soil washing is treated on site prior to discharge. A bio-slurry reactor is a hybrid soil washing technique that is used to treat a slurry of wastewater and contaminated soil. An aqueous slurry is created by combining soil, sediment, or sludge with water and other additives. The slurry is mixed to keep solids suspended and microorganisms in contact with the soil contaminants. Upon completion of the process, the slurry is dewatered and the treated soil is disposed or returned to the excavation. Material processing equipment (mixing unit and batch tanks) and water treatment equipment will require room for setup near one of the excavation areas. A mobile unit will be used to treat (wash) soil on site. Treated soil will be returned to the excavation as backfill material. Semi-volatile organics and hydrophobic contaminants may require the addition of a surfactant or organic solvent. A bench or pilot-scale treatability test may be needed to determine the best operating conditions and wash fluid compositions for soil washing and or bio-slurry treatment.

On site soil washing can also be applied to contaminated material in the upper bluff area, and limited areas in Kreher Park, as described for the limited removal alternatives previously described (Alternatives S-3A, S-4, S-5A, and S-5B). As with on site thermal treatment, man-made fill material (i.e. ashes, cinders, bricks, concrete, wood debris, and glass) is not suitable for soil washing and will require separation and off site disposal. The presence of wood waste in Kreher Park and fly-ash and cinders in the filled ravine (on the north side of St. Claire Street in the upper bluff area) will preclude the use of soil washing of debris from these areas. Consequently, soil washing will be used for contaminated fill soil removed from areas with high concentrations of VOCs and PAH compounds at Kreher Park and the upper bluff area. Residual soil and groundwater contamination may remain, which may require natural attenuation and institutional controls for site closure if contaminants remain above RAOs.

Limited removal and on site soil washing will be limited to areas with the highest levels of contamination. This includes the former gas holder at the upper bluff area where NAPL has been encountered, and the former coal tar dump area at Kreher Park. The lateral extent of these excavations are shown on Figure 2-1. Key elements of the conceptual design for limited removal and ex-situ soil washing in the upper bluff area and Kreher Park are as follows:

1. Soil washing and ancillary equipment will be set up at Kreher Park because inadequate space is available at the upper bluff area.
2. Demolition of the center section of the NSPW service center for excavation south of St. Claire Street will be required to access contaminated soil beneath the building at the upper bluff area.
3. Removal of existing asphalt pavement from the alley and courtyard area will also be required.
4. All shallow water table wells screened in the fill soil unit will be abandoned prior to excavation. Piezometers screened in the underlying Copper Falls aquifer will be protected during excavation and backfilling activities and remain in place for future use.
5. Removal will include the excavation of soil containing NAPL, and the removal of buried structures (i.e. former gas holders) at the upper bluff area south of St. Claire Street. This area includes the excavation of unsaturated and saturated zone soils to a depth between 12 and 15 feet for an area approximately 130 feet by 130 feet, yielding between 7,600 and 9,400 cubic yards. Also included for removal will be soil containing NAPL in the ravine on the north side of St. Claire Street. This will include the excavation of saturated zone soil from the bottom five feet of the filled ravine where the clay tile and NAPL were encountered. At the surface, this excavation area will be approximately 30 feet by 75 wide. An estimated 75 to 150 cubic yards of NAPL contaminated soil will be removed from the base of the filled ravine.
6. Removal will also include the excavation of unsaturated and saturated zone soils at the former coal tar dump area. This includes approximately 5 feet of contaminated soil in an area approximately 280 feet by 130 feet, yielding approximately 4,000 cubic yards.
7. Deep excavations, or excavations completed near facility buildings may require shoring to support sidewalls.
8. Groundwater seeping into the excavation will be collected, temporarily placed in holding tanks, and treated by the on site treatment system prior to discharge to the sanitary sewer.
9. Saturated and unsaturated zone material will be treated by soil washing to reduce contaminant mass and toxicity, and returned to the excavation as back fill. Material unsuitable for soil washing will be transported off site for landfill disposal.
10. Site restoration will include the installation of new asphalt pavement as a surface barrier over the excavated area south of St. Claire Street, and new asphalt pavement at the gravel covered courtyard area on the north side of the street. The existing street (inspected for water tightness and sealed or replaced as needed) and new asphalt pavement on the

NSPW property will prevent exposure to fill material beneath St. Claire Street and the NSPW storage yard.

11. Site restoration at Kreher Park will include backfilling with clean fill material, and installation of a new RCRA Class C or D cap or asphalt road or parking lot over the Kreher Park area.
12. Long-term operation and maintenance for the site will include groundwater monitoring and periodic inspection and repair of all asphalt caps.

Table2-1 - Summary of Potential Remedial Alternatives for Soil

Soil Remediation	Alternative S1 No Action	Alternative S2 Containment using Engineered Surface Barriers	Alternative S3A Limited Removal and Off site Disposal	Alternative S3B Unlimited Removal and Off site Disposal	Alternative S4 Limited Removal and On site Disposal	Alternative S5A Limited Removal and On site Thermal Treatment	Alternative S5B Limited Removal and Off site Incineration	Alternative S6 Limited Removal and Onsite Soil Washing
Removal /Treatment Volume (cubic yards)								
Upper Bluff Area	0	32,500	7,675 to 9,650	32,500	7,675 to 9,650	7,675 to 9,650	7,675 to 9,650	7,675 to 9,650
Kreher Park	0	4,000	4,000	223,000	4,000	4,000	4,000	4,000
Removal /Treatment Method								
Upper Bluff Area	None	No treatment prior to capping.	No treatment prior to disposal.	No treatment prior to disposal.	No treatment prior to disposal.	On site thermal treatment staged at Kreher Park.	Off site incineration and disposal.	On site soil washing staged at Kreher Park
Kreher Park	None							
Disposal Required								
Upper Bluff Area	No removal or treatment of contaminated soil.	No removal or treatment of contaminated soil.	Transport all material to existing off site NR 500 landfill for disposal.	Site and construct new nearby off site NR 500 landfill for disposal of all material.	Site and construct new disposal cell at Kreher Park for disposal of all excavated material.*	Transport debris not suitable for treatment to an existing off site NR 500 landfill for disposal.	Transport debris not suitable for treatment to an existing off site NR 500 landfill for disposal.	Transport debris not suitable for treatment to an existing off site NR 500 landfill for disposal.
Kreher Park								
Excavation Dewatering Required								
Upper Bluff Area	No	No	Yes – utilize on site treatment system.	Yes – utilize on site treatment system.**	Yes – utilize on site treatment system.*	Yes – utilize on site treatment system.	Yes – utilize on site treatment system.	Yes – utilize on site treatment system.
Kreher Park								
Backfill								
Upper Bluff Area	None	None	Clean fill from off site source.	Clean fill from Kreher Park.	Clean fill from Kreher Park.	Return treated soil to excavation, and fill to grade with clean fill from an off site source.	Clean fill from off site location.	Return treated soil to excavation, and fill to grade with clean fill from an off site source.
Kreher Park				Clean fill from off site location as needed. .				
Site Restoration								
Upper Bluff Area	None	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.	Asphalt pavement over former ravine.
Kreher Park		Cap over former coal tar dump area.	Cap over former coal tar dump area.	Restore Kreher Park to pre-removal elevations with clean fill. or	Cap over former coal tar dump area.	Cap over former coal tar dump area.	Cap over former coal tar dump area.	Cap over former coal tar dump area

Soil Remediation	Alternative S1	Alternative S2	Alternative S3A	Alternative S3B	Alternative S4	Alternative S5A	Alternative S5B	Alternative S6
	No Action	**Containment using Engineered Surface Barriers**	**Limited Removal and Off site Disposal**	**Unlimited Removal and Off site Disposal**	**Limited Removal and On site Disposal**	**Limited Removal and On site Thermal Treatment**	**Limited Removal and Off site Incineration**	**Limited Removal and Onsite Soil Washing**
				restoration as wetland or shallow lakebed.				
Other Remedial Technologies Used								
Upper Bluff Area	MNA Instit. Cntrls. Surface Barriers Vertical Barriers	MNA Instit. Cntrls Vertical Barriers	MNA Instit. Cntrls Surface Barriers Vertical Barriers	MNA Institutional Cntrls	MNA Instit. Cntrls Surface Barriers Vertical Barriers CDF	MNA Instit. Cntrls Surface Barriers Vertical Barriers	MNA Instit. Cntrls Surface Barriers Vertical Barriers	MNA Instit. Cntrls Surface Barriers Vertical Barriers
Kreher Park				MNR Vertical Barriers				

* Disposal cell could be enlarged for on site disposal of sediment.
** May include use of sediment de-watering treatment equipment if sediment removal is selected for off-shore contamination.

2.4 Evaluation of Potential Remedial Alternatives for Soil

Potential remedial alternatives for soil were evaluated in this section in accordance with the threshold criteria, primary balancing criteria, and modifying criteria described in Section 1.4 above.

2.4.1 Threshold Criteria

Threshold criteria, which relate to statutory requirements that each alternative must satisfy to be eligible for selection, include:

- Overall protection of human health and the environment; and
- Compliance with ARARs.

The "no action" alternative will not satisfy threshold criteria; it will not result in the protection of human health and the environment. The remaining potential remedial alternatives for soil (removal and off site disposal and removal and ex-situ treatment) will result in a reduction in mass, toxicity, or mobility of contaminants, which will result in the overall protection of human health and the environment.

The "no action" alternative will not achieve compliance with ARARs. However, the remaining potential remedial alternatives for soil will achieve compliance with ARARs, which are summarized in Table 1 in Attachment 1. Remedial responses for soil were screened in the Alternative Screening Technical Memorandum, and responses that were retained for screening were further evaluated in this report. Remedial responses that would not protect human health and the environment or achieve compliance with ARARs were not retained for screening.

2.4.2 Balancing Criteria

The primary *balancing criteria*, which are the technical criteria upon which the detailed analysis is primarily based, include:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

A summary of the balancing criteria for each potential remedial alternative for soil follows.

2.4.2.1 Long Term Effectiveness and Permanence

Each remedial alternative is evaluated as to magnitude of long-term residual risks, adequacy of controls, and reliability of long-term management controls in restoring soil contamination. Table 2-2 presents an evaluation of the long-term effectiveness and permanence of each alternative.

Table 2-2 - Evaluation of Long-term Effectiveness and Permanence
For Potential Soil Remedial Alternatives

Alternative	Magnitude and Type of Residual Risk	Adequacy and Reliability of Controls
Alternative S1 No Action	• Potential risk to human health or the environment would not be reduced.	• There are no remedial actions or controls associated with this alternative.
Alternative S2 Containment using Engineering Surface Barriers	• Contaminants will remain in soil beneath a surface barrier that will prevent direct contact. • Surface barriers will also reduce infiltration and minimize leaching to groundwater.	• Surface barriers will effectively prevent direct contact with contaminated soil and reduce infiltration. • Reliability is high through maintenance of barriers and institutional controls; these can easily be implemented. • Most effective if used in conjunction with a remedial response for groundwater.
Alternative S3A Limited Removal and Off site Disposal	• Limited removal of source areas containing NAPL and elevated concentrations of VOCs and PAHs will minimize residual soil contamination. • Other contaminants (i.e. metals) and groundwater contamination may remain. • Site restoration will include surface barriers to prevent direct contact with subsurface residual contamination and reduce infiltration to minimize leaching to groundwater.	• Removal of shallow soil from filled ravine and former coal tar dump area with conventional earth moving equipment is highly reliable. • Removal of source areas containing NAPL and elevated concentrations of VOCs and PAH compounds would sufficiently reduce risk to human health and the environment. • Surface barrier maintenance will be required to maximize reliability of remedial response. Institutional controls could be easily implemented to prevent long-term exposure to residual subsurface contamination.
Alternative S3B Unlimited Removal and Off site Disposal	• This remedial response will results in the removal of contaminated and un-contaminated fill material. • Unlimited removal of all fill material will minimize potential for residual contamination. • Construction of an off site landfill would likely be required for large volume of material.	• Removal of shallow soil from filled ravine with conventional earth moving equipment is highly reliable, but would require removal and replacement of buried utilities and section of City street, which may be difficult to implement. • Significant contamination is present at base of fill in Kreher Park, but removal of fill material below lake level will be difficult to implement. • Kreher Park restoration may require placement of clean fill, or restoration of former lakebed as wetland area or shallow lakebed.

Table 2-2 - Evaluation of Long-term Effectiveness and Permanence For Potential Soil Remedial Alternatives

Alternative	Magnitude and Type of Residual Risk	Adequacy and Reliability of Controls
Alternative S4 Limited Removal and On site Disposal ***Alternative S5A*** Limited Removal and On site Thermal Treatment ***Alternative S5B*** Limited Removal and Off site Incineration	• Limited removal of source areas containing NAPL and elevated concentrations of VOCs and PAHs will minimize residual soil contamination. • Other contaminants (i.e. metals) and groundwater contamination may remain. • Site restoration will include surface barriers over excavated area and over disposal cell to prevent direct contact with subsurface residual contamination and reduce infiltration to minimize leaching to groundwater. • Groundwater monitoring will likely be needed to evaluate on-going risk to human health and the environment	• Removal of shallow soil from filled ravine and former coal tar dump area with conventional earth moving equipment is highly reliable. • Although other contaminants may remain, removal of source areas containing NAPL and elevated concentrations of VOCs and PAH compounds would significantly reduce risk to human health and the environment. • Minimal long-term maintenance and monitoring will be required to evaluate reliability. Institutional controls could be easily implemented to prevent long-term exposure to residual subsurface contamination, treated material placed as backfill, and contaminated material placed in disposal cell.
Alternative S6 Limited Removal and onsite Soil Washing	• Limited removal of source areas containing NAPL and elevated concentrations of VOCs and PAHs will minimize residual soil contamination. • Site restoration for limited removal will include surface barriers to prevent long-term exposure to subsurface residual contamination and reduce infiltration to minimize leaching to groundwater. • Groundwater monitoring will likely be needed to evaluate on-going risk to human health and the environment	• Removal with conventional earth moving equipment is highly reliable, but residual contamination may remain in treated soil. • Long-term monitoring will be required following on site placement of treated soil to evaluate reliability. • Minimal long-term surface barrier maintenance and monitoring will be required to evaluate reliability of remedial response. Institutional controls could be easily implemented to prevent long-term exposure to residual subsurface contamination and treated material placed as backfill.

2.4.2.2 Reduction of Toxicity, Mobility or Volume through Treatment

The remedial alternatives are evaluated for permanence and completeness of the remedial action in significantly reducing the toxicity, mobility, or volume of hazardous materials through treatment. Each alternative is evaluated based on the treatment processes used, the volume or amount and degree to which it destroys or treats hazardous materials; the expected reduction in toxicity, mobility, or volume provided by the alternative; the extent to which the treatment is irreversible; and the types and quantities of residuals that will remain following treatment. Table 2-3 presents a summary of this evaluation.

Table 2-3 - Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment For Potential Soil Remedial Alternatives

Alternative	Treatment Process Used and Materials Treated	Volume of Material Removed Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative S1 No Action	None	None	None	Not applicable	Not applicable
Alternative S2 Containment using Engineering Surface Barriers	No material treated; surface barrier used to prevent direct contact.	None	No reduction in contaminant mass or toxicity, but will reduce infiltration and minimize mobility of contaminants leaching to groundwater.	Surface barriers could easily be removed.	Contaminated soil will remain in place beneath surface barriers placed over the filled ravine and former coal tar dump areas; the wood waste layer at Kreher Park will remain in place.
Alternative S3A Limited Removal and Off site Disposal	No treatment prior to disposal at off site landfill.	7,675 to 9,650 cubic yards removed from upper bluff area, and 4,000 cubic yards removed from the former coal tar dump area.	Removal of highly contaminated fill where NAPL is present will result in significant reduction of contaminant mass Reduction of toxicity, mobility and volume reduction is expected to be high.	Off site disposal would be irreversible.	Residual contamination may remain in the filled ravine and former coal tar dump area; the wood waste layer at Kreher Park will remain in place.
Alternative S3B Unlimited Removal and Off site Disposal	No treatment prior to disposal at off site landfill.	32,500 cubic yards removed from the upper bluff area and 223,000 cubic yards removed from Kreher Park.	Removal of all fill material containing high and low levels of contamination will result in significant reduction of contaminant mass. Reduction of toxicity, mobility and volume reduction is expected to be very high.	Off site disposal would be irreversible.	All fill soil containing high and low levels of contamination removed. The wood waste layer at Kreher Park will be removed. Little to no residual soil contamination would be expected.

Table 2-3 - Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment For Potential Soil Remedial Alternatives

Alternative	Treatment Process Used and Materials Treated	Volume of Material Removed Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative S4 Limited Removal and On site Disposal	No treatment prior to disposal at on site disposal cell landfill.	7,675 to 9,650 cubic yards removed from the upper bluff area. Nothing removed from Kreher Park, and 4,000 cubic yards removed from the former coal tar dump area..	Removal of highly contaminated fill will result in significant reduction of contaminant mass Reduction of toxicity, mobility and volume reduction is expected to be high.	Material placed in disposal cell at Kreher Park would remain in place, or transported off site at a later time.	Residual contamination may remain in fill at upper bluff area and at former coal tar dump area; the wood waste layer at Kreher Park will remain in place.
Alternative S5A Limited Removal and On site Thermal Treatment	On site thermal treatment to remove contaminants. Return treated soil to excavation.	7,675 to 9,650 cubic yards removed from upper bluff area, and 4,000 cubic yards removed from the former coal tar dump area.	Removal and thermal treatment of highly contaminated fill where NAPL is present will result in significant reduction of contaminant mass. Reduction of toxicity, mobility and volume is expected to be high.	Thermal treatment would be irreversible; treated soil would remain in place as back fill, or transported off site at a later time.	Residual contamination may remain in untreated fill at the upper bluff and at the former coal tar dump area; the wood waste layer at Kreher Park would remain in place.
Alternative S5B Limited Removal and Off site Incineration	Off site incineration to treat contaminated soil. Clean fill used to back fill excavated areas.			Incineration would be irreversible.	

Table 2-3 - Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment For Potential Soil Remedial Alternatives

Alternative	Treatment Process Used and Materials Treated	Volume of Material Removed Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative S6 Limited Removal and onsite Soil Washing	Soil washing to remove contaminants. Return treated soil to excavation.	7,675 to 9,650 cubic yards removed from upper bluff area, and 4,000 cubic yards removed from the former coal tar dump area.	Removal of highly contaminated fill will result in significant reduction of contaminant mass. Reduction of toxicity, mobility and volume reduction is expected to be high.	Soil washing would be irreversible; treated soil would remain in place as back fill, or transported off site at a later time.	Residual contamination may remain in untreated fill at the upper bluff and at the former coal tar dump area; the wood waste layer at Kreher Park would remain in place.

2.4.2.3 Short Term Effectiveness

The evaluation of short-term effectiveness is based on the degree of protectiveness of human health achieved during construction and implementation of the remedy. Potential implementation risks to the community and site workers and mitigation measures for addressing those risks are included in this evaluation. In addition, environmental impacts during implementation and the time required to achieve the RAOs must also be considered in the evaluation of this criterion. Table 2-4 summarizes the results of this evaluation.

Table 2-4 - Evaluation of Short Term Effectiveness for Potential Soil Remedial Alternatives

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
Alternative S1 No Action	None	No additional impact to the environment	RAOs will not be achieved.
Alternative S2 Containment using Engineering Surface Barriers	Actions to protect community and site workers during remediation can be implemented.	Surface barrier will reduce infiltration and minimize leaching to groundwater, but long-term source for groundwater contamination will remain.	Direct contact exposure route can be eliminated in a short time frame, but contaminants will remain beneath surface barrier for an extended period of time.
Alternative S3A Limited Removal and Off site Disposal		Significant contaminant mass will be removed from highly contaminated areas where NAPL is present. Residual contaminants may remain on site.	Site work can be completed in a short time frame. Post remediation monitoring for residual contamination remaining on site may be needed to ensure compliance with RAOs.
Alternative S3B Unlimited Removal and Off site Disposal		All fill material including contaminated and uncontaminated material will be removed from fill ravine and at upper bluff and Kreher Park; minimal residual contamination may remain.	Site work can be completed in a short time frame, and verification soil samples collected following removal of all material will be used to determine compliance with RAOs.
Alternative S4 Limited Removal and On site Disposal		Significant contaminant mass will be removed from highly contaminated areas where NAPL is present. Residual contaminants may remain on site.	Site work can be completed in a short time frame, and verification soil samples collected following removal of all material will be used to determine compliance with RAOs. Long term monitoring will be required to ensure disposal cell compliance with RAOs.

Table 2-4 - Evaluation of Short Term Effectiveness for Potential Soil Remedial Alternatives

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
Alternative S5A Limited Removal and On site Thermal Treatment	Actions to protect community and site workers during remediation can be implemented.	Significant contaminant mass will be removed from highly contaminated areas where NAPL is present. Residual contaminants may remain on site.	Site work can be completed in short time frame. Post remediation monitoring for residual contamination remaining on site may be needed to ensure compliance with RAOs. Long-term monitoring may be needed for areas backfilled with treated soil.
Alternative S5A Limited Removal and Off site Incineration			Site work can be completed in a short time frame, and verification soil samples collected following removal of all material will be used to determine compliance with RAOs.
Alternative S6 Limited Removal and onsite Soil Washing	Actions to protect community and site workers during remediation can be implemented.	Significant contaminant mass will be removed from highly contaminated areas where NAPL is present. Residual contaminants may remain on site.	Site work can be completed in short time frame. Post remediation monitoring for residual contamination remaining on site may be needed to ensure compliance with RAOs. Long-term monitoring may be needed for areas backfilled with treated soil.

2.4.2.4 Implementability

Implementability is based on the evaluation of technical feasibility, administrative feasibility, and the availability of services and materials. Technical feasibility considers the following factors:

- difficulties that may be inherent during construction and operation of the remedy;
- the reliability of the remedial processes involved;
- the flexibility to take additional remedial actions, if needed;
- the ability to monitor the effectiveness of the remedy;
- the availability of offsite treatment, storage, and disposal facilities; and,
- the availability of needed equipment and specialists.

Administrative feasibility considers permitting and regulatory approval and coordination with other agencies. Table 2-5 presents a summary of this evaluation.

Table 2-5. Evaluation of Implementability for Potential Soil Remedial Alternatives

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
Alternative S1 No Action	Additional remedial actions could be easily implemented.	Not applicable.	No permitting required, but will likely not be able to obtain regulatory approval.	None required.
Alternative S2 Containment using Engineering Surface Barriers	Installation is technically feasible for areas where fill and/or subsurface contamination are present.	Reliable technology for elimination of direct contact exposure route and reduction of infiltration.	Regulatory approval likely if implemented with remedial response for shallow groundwater contamination.	Conventional construction equipment could be used for construction of surface barriers.
Alternative S3A Limited Removal and Off site Disposal	Excavation is feasible technology for remediation of contaminated soil. Likely that removal and off site disposal of all fill soil containing NAPL and high VOC and PAH concentrations will result in a significant reduction of contaminant mass.	Highly reliable technology; most commonly used remedial technology for contaminated soil at MGP sites.	Regulatory approval likely. Selection of landfill for off site disposal would be required.	Conventional earth moving and excavation de-watering equipment would be used. Groundwater would be treated on site with existing equipment.
Alternative S3B Unlimited Removal and Off site Disposal	Removal of all fill material from filled ravine is feasible, but excavation of saturated fill at Kreher Park below lake level may be difficult. A landfill may need to be sited and constructed for disposal of the large volume of contaminated soil.	Reliable technology; most commonly used for contaminated soil at MGP sites However, removal of all fill material may not be needed to achieve compliance with RAOs.	Regulatory approval likely. Would require siting and construction of landfill for off site disposal, and approval of restoration of Kreher Park to either pre-filling (i.e. wetland, or shallow lake bottom), or pre-removal conditions.	Conventional earth moving and excavation de-watering equipment would be used. Groundwater would be treated on site using equipment used for sediment remediation.

Table 2-5. Evaluation of Implementability for Potential Soil Remedial Alternatives

<table>
<tr><th>Alternative</th><th>Technical Feasibility</th><th>Reliability of Technology</th><th>Administrative Feasibility</th><th>Availability of Services and Materials</th></tr>
<tr><td><u>Alternative S4</u>
Limited Removal and On site Disposal</td><td>Disposal cell construction at Kreher Park is technically feasible. Long-term maintenance and monitoring of disposal cell will likely be completed in combination with containment of Kreher Park using surface and vertical barriers walls (evaluated as a groundwater remedial alternative).</td><td>Reliable technology, but not commonly used for contaminated soil at MGP sites due to land-use limitations.</td><td>Regulatory approval likely. Would require siting and construction of disposal cell for on site disposal.</td><td rowspan="2">Conventional earth moving, thermal treatment and excavation de-watering equipment would be used. Groundwater would be treated on site with existing equipment.</td></tr>
<tr><td><u>Alternative S5A</u>
Limited Removal and On site Thermal Treatment</td><td>On site thermal treatment is a feasible technology for remediation of contaminated soil at MGP sites. Likely that removal and off site disposal of all fill soil containing NAPL and high VOC and PAH concentrations will result in a significant reduction of contaminant mass.</td><td>Highly reliable technology; it is commonly used for contaminated soil at MGP sites. Would require separation and off site disposal of debris not suitable for thermal treatment.</td><td>Regulatory approval likely. Discharge permits for air and waste water may be needed.</td></tr>
<tr><td><u>Alternative S5B</u>
Limited Removal and Off site Incineration</td><td>Off site incineration is technically feasible, but will be more costly than on site thermal treatment.
Likely that removal and off site incineration of all fill soil containing NAPL and high VOC and PAH concentrations will result in a significant reduction of contaminant mass.</td><td>Highly reliable technology; but incineration may not be needed to achieve RAOs. Would require separation and off site disposal of debris not suitable for incineration.</td><td>Regulatory approval likely. Selection of facility for off site incineration would be required.</td><td>Incineration most commonly performed at off site facilities due to specially equipment and required air permits.</td></tr>
</table>

Table 2-5. Evaluation of Implementability for Potential Soil Remedial Alternatives

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
Alternative S6 Limited Removal and onsite Soil Washing	Pilot test would be needed to evaluate reliability of soil washing. Likely that removal of all fill soil containing NAPL and high VOC and PAH concentrations will result in a significant reduction of contaminant mass	Pilot test will need to be completed to evaluate reliability of technology; technology not commonly used for contaminated soil at MGP sites.	Regulatory approval likely. Discharge permits for air and waste water may be needed.	Conventional earth moving, soil washing and excavation de-watering equipment would be used. Groundwater would be treated on site with existing equipment.

2.4.2.5 Cost

Preliminary estimated costs for potential soil remedial alternatives include estimated costs for site preparation, excavation, excavation de-watering, transportation and disposal, on site treatment, and site restoration. Annual operation, maintenance, and monitoring (OM&M) costs are not estimated for each alternative. It is assumed the OM&M following soil remediation will be completed concurrent with OM&M following groundwater remediation. Consequently, OM&M costs are included with potential groundwater remedial alternatives costs in Section 3. Additionally it is assumed that all work is contracted and the estimates do not account for possible economies of scale (i.e., completing all activities at the site concurrently). These cost estimates are developed primarily for the purpose of comparing remedial alternatives and not for establishing project budgets. Detailed cost estimates will be presented in the Feasibility Study in accordance with the USEPA guidance document, *A Guide to Developing and Documenting Cost Estimates* (EPA and USACE, 2000). Table 2-6 presents a summary of the cost evaluation.

<table>
<tr><th colspan="3">Table 2-6. Evaluation of Cost for Potential Soil Remedial Alternatives</th></tr>
<tr><th>Alternative</th><th>Upper Bluff Area</th><th>Kreher Park</th></tr>
<tr><td>Alternative S1 No Action</td><td>$0</td><td>$0</td></tr>
<tr><td>Alternative S2 Containment Using Engineered Surface Barriers</td><td>$184,000</td><td>$176,000</td></tr>
<tr><td>Alternative S3A Limited Removal and Off site Disposal</td><td>$1,068,000</td><td>$485,000</td></tr>
<tr><td>Alternative S3B Unlimited Removal and Off site Disposal (restore Kreher Park as wetland)</td><td rowspan="2">$1,525,000</td><td>$14,715,000</td></tr>
<tr><td>Alternative S3B Unlimited Removal and Off site Disposal (backfill Kreher Park with clean fill)</td><td>$19,504,000</td></tr>
<tr><td>Alternative S4 Limited Removal and On site Disposal</td><td>$916,000</td><td>$1,298,000*</td></tr>
<tr><td>Alternative S5A Limited Removal and Ex-situ Thermal Treatment</td><td>$946,000</td><td>$518,000</td></tr>
<tr><td>Alternative S5B Limited Removal and Off site Incineration</td><td>$3,412,000</td><td>$1,240,000</td></tr>
<tr><td>Alternative S6 Limited Removal and Ex-situ Soil Washing</td><td>$1,370,000</td><td>$1,201,000</td></tr>
</table>

* Includes only construction of one acre disposal cell in Kreher Park.

2.4.3 Modifying Criteria

The third group, the *modifying criteria*, includes:

- State/Support agency acceptance
- Community acceptance.

As previously discussed, these last two criteria are typically formally evaluated following the public comment period, although they can be factored into the identification of the preferred alternative to the extent practicable.

2.5 Comparative Analysis of Potential Remedial Alternatives for Soil

In this section, as required by CERCLA and NCP regulations, the alternatives will undergo a comparative evaluation wherein the advantages and disadvantages of the alternatives will be concurrently assessed with respect to each criterion. The criteria considered as part of this comparative evaluation are defined in Section 2.4. Table 2-7 presents a summary of the comparative analysis.

Table 2-7 – Comparison of Potential Soil Remedial Alternatives

Criteria	Alt. S1 No Action	Alt. S2 Containment using Engineered Surface Barriers	Alt. S3A Limited Removal and Off site Disposal	Alt. S3B Unlimited Removal and Off site Disposal	Alt. S4 Limited Removal and On site Disposal	Alt. S5A Limited Removal and On site Thermal Treatment	Alt. S5B Limited Removal and Off site Incineration	Alt. S5 Limited Removal and Ex-situ Soil Washing
Overall Protection of Human Health and the Environment	None	Low	High	High	Moderate	High	High	Moderate to High
Compliance with ARARs and TBCs	None	Low	High	High	Low to Moderate	High	High	Moderate to High
Long-term Effectiveness and Permanence	None	Low	High	High	Low to Moderate	High	High	Moderate to High
Reduction of Toxicity, Mobility and Volume through Treatment	None	Low	High	High	Low to Moderate	High	High	Moderate to High
Short-term Effectiveness	Low	High	High	High	Moderate	High	High	High
Implementability	None	High	High	Low to Moderate	High	High	Low to Moderate	Moderate
Cost	Low	Low	Moderate	Very High	Moderate	High	Very High	High
Agency Acceptance	None	Low	High	High	Low to Moderate	High	High	Low to Moderate
Community Acceptance	None	Low	High	Low to Moderate	Low	Moderate	High	Low to Moderate

2.5.1 Overall Protection of Human Health and the Environment

Alternative S1 (no action) offers no additional protection for human health and the environment because no additional actions would be taken to address soil contamination at the Site. ***Alternative S3B*** (unlimited removal and off site disposal) offers the highest level of protection of human health and the environment in the long-term because all fill and contaminated soil would be removed. ***Alternative S3A*** (limited removal and off site disposal), ***Alternative S5A*** (limited removal and on site thermal treatment), and ***Alternative S5B*** (limited removal and incineration) would also offer high levels of protection because these remedial responses would result in the removal of a significant contaminant mass. ***Alternative S6*** (limited removal and treatment by soil washing) would offer moderate to high level of overall protection of if this technology can be implemented to effectively reduce contaminant concentrations. ***Alternative S2*** (containment using engineered surface barriers) will eliminate the direct contact exposure route, but will provide a low level of overall protection because soil contamination will remain. ***Alternative S4*** (limited removal and on site disposal) will provide a moderate level of human health and the environment because highly contaminated material from the upper bluff area and the former coal tar dump area will be consolidated into a disposal cell at Kreher Park. .

Although unlimited removal for Alternative S3B will provide high level of human health and environmental protection, limited removal for Alternatives S-3A, S-5A, S-5B, and S-6 will also provide adequate protection because these remedial responses will result in the removal of a significant mass of contamination. Although Alternatives S-2 and S-4 will result in the containment of contaminated materials, which will be inaccessible to humans or biota, thereby reducing risk, the overall level of protection are lower because there is no reduction on contaminant mass.

2.5.2 Compliance with ARARs and TBCs

Alternative S1 (no action) will not achieve compliance with ARARs and TBCs. Implementation will require that engineering and construction actions be developed and completed in compliance with federal and state regulations. ***Alternatives S2 and S4*** (surface barriers and limited removal and on site disposal) must be implemented with a groundwater remedial response to achieve compliance. If properly implemented, the remaining remedial responses could achieve compliance with ARARs and TBCs for soil.

2.5.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence considers long-term residual risks, adequacy of controls, and reliability of long-term management controls in restoring soil contamination. ***Alternative S1*** (no action) will not provide any long-term benefit; no additional actions will be taken to address soil contamination at the Site. ***Alternative S3B*** (unlimited removal and off site disposal) will provide the highest effectiveness and permanence over the long term because all contaminated material and fill soil would be removed. ***Alternative S3A*** (limited removal and off site disposal), ***Alternative S5A*** (limited removal and ex-situ thermal treatment), and ***Alternative***

S5B (limited removal and incineration will also highly effective and permanent over the long term because these responses will result in the removal of a significant mass of contamination. ***Alternative S6*** (limited removal and treatment by soil washing) will provide low moderate to high levels of effectiveness and permanence over the long term; effectiveness will depend upon the reduction in contaminant concentrations that can be achieved with this technology. The long-term effectiveness of ***Alternative S4*** (limited removal and on site disposal) is considered low to moderate because contaminants will remain on site in a disposal cell constructed at Kreher Park. The long-term effectiveness of ***Alternative S2*** (containment using engineered surface barriers) is considered low because constituents will remain at the site beneath the surface barriers. However, for Alternatives S-2 and S-4, contaminated material will be contained and inaccessible to humans or biota, thereby reducing risk.

If properly implemented, the long-term effectiveness and permanence for all alternatives can be achieved for all active remedial responses for soil. Surface barriers (Alternative S2) must be implemented in conjunction with a remedial response for groundwater to be more effective.

2.5.4 Reduction of Toxicity, Mobility, and Volume Through Treatment

Reduction of toxicity, mobility, or volume of hazardous materials through treatment considers the treatment processes used, the volume or amount and degree to which it destroys or treats hazardous materials; the expected reduction in toxicity, mobility, or volume provided by the alternative; the extent to which the treatment is irreversible; and the types and quantities of residuals that will remain following treatment. ***Alternative S1*** (no action) will not result in a reduction in the toxicity, mobility, or volume of contaminated soil. ***Alternative S3B*** (unlimited removal and off site disposal) will result in the highest degree of reduction of toxicity, mobility, and volume of impacted material because all contaminated soil and fill material will be removed. ***Alternative S3A*** (limited removal and off site disposal), ***Alternative S5A*** (limited removal and ex-situ thermal treatment), and ***Alternative S5B*** (limited removal and incineration) will also result in a high degree of reduction of toxicity, mobility, and volume of impacted material because these remedial responses will remove a significant contaminant mass. ***Alternative S-6*** (limited removal and treatment by soil washing) will result in a moderate to high degree of reduction of toxicity, mobility, and volume of contaminated soil, but will depend upon the reduction in contaminant concentrations that can be achieved with this technology. ***Alternative S-4*** (limited removal and on site disposal) will offer a low to moderate reduction in the toxicity, mobility, and volume of contaminated soil at the Site. It will effectively reduce the toxicity and a significant volume of contaminated soil at the upper bluff area and former coal tar dump area, but this material will be placed in a disposal cell at Kreher Park, which will reduce the mobility of these contaminants. ***Alternative S2*** (containment using engineered surface barriers) will not reduce the toxicity or and volume of contaminated soil in unexcavated areas, but it will limit the mobility of contaminants by reducing infiltration, which will minimize contaminant leaching to groundwater.

2.5.5 Short-term Effectiveness

Short-term effectiveness considers potential implementation risks to the community and site workers, environmental impacts, and time required to achieve RAOs. Implementation of **Alternative S1** (no action) will not achieve RAOs or improve environmental impacts in the short-term. Because there is no remediation, there will be no exposure to the community and workers. The remaining alternatives will improve environmental impacts in the short-term, but require significant effort to protect the community and workers during remediation. Implementation of ***Alternative S3B*** (unlimited removal and off site disposal) will result in the most significant on and off site site disturbance and require the highest levels of effort for this protection. ***Alternative S4*** (limited removal and on site disposal) will result in no off site disturbance; site disturbance will be limited to the site, and will require a moderate level of effort for protection. ***Alternative S2*** (containment using engineered surface barriers) will results in minimal on site disturbance, and no off site disturbance. Because the remaining alternatives include limited removal of highly contaminated soil, they will require high levels of effort for worker and community protection. If properly implemented, all alternatives, can achieve short term effectiveness for soil. . Surface barriers (Alternative S2) must be implemented in conjunction with a remedial response for groundwater to be more effective

2.5.6 Implementability

Implementability considers technical feasibility, administrative feasibility, and the availability of services and materials. **Alternative S1** (no action) will require the least amount of effort for implementability. Additionally, because no remedial action will occur, there will be no difficulty in implementing additional remedial actions at a later date. ***Alternative S3B*** (unlimited removal and off site disposal) will result in significant site disturbance, and will be the most difficult to implement. ***Alternative S6*** (limited removal and treatment by soil washing) may require a pilot test to evaluate its implementability. The remaining limited removal alternatives are highly implementable.

2.5.7 Cost

Preliminary cost estimates for potential remedial alternatives for soil include site preparation, excavation, excavation de-watering, transportation and disposal, on site treatment, and site restoration. There are no costs associated with ***Alternative S1*** (no action) because none of these activities will be completed. For the upper bluff area, the ***Alternatives S3B*** (unlimited removal and off site disposal) and ***Alternative S5B*** (limited removal and incineration) yielded the highest costs. ***Alternative S6*** (limited removal and treatment by soil washing) yielded the next highest cost, following by **Alternative 3A** (limited removal and off site disposal), and ***AlternativeS5A*** (unlimited removal and on site thermal treatment). ***Alternatives S4*** (limited removal and on site disposal) yielded lower costs for the upper bluff area compared to the off site disposal and on site treatment alternatives, but would require construction of a disposal cell in Kreher Park; this alternative does not include soil or groundwater remediation in Kreher Park. ***Alternative S2*** (containment using engineered surface barriers) would be the lowest cost remedial response for soil in the upper bluff area, but would likely need to be completed in conjunction with a groundwater remedial response to be effective.

Alternative S3B (unlimited removal and off site disposal) also yielded the highest cost for Kreher Park. ***Alternative S5B*** (limited removal and incineration) yielded the next highest cost followed by ***Alternative S4*** (limited removal and on site disposal), ***Alternative S6*** (limited removal and treatment by soil washing), ***Alternative S5A*** (limited removal and on site thermal treatment), and ***Alternative S3A*** (limited removal and off site disposal). ***Alternative S2*** (containment using engineered surface barriers) yielded the lowest cost, but would likely need to be completed in conjunction with a groundwater remedial response to be effective.

2.5.8 Agency and Community Acceptance

No action alternative (Alternative 1) for soil will not be acceptable to the community or regulatory agencies. ***Alternative S2*** (containment using engineered surface barriers) could be acceptable to the community and regulatory agencies if implemented with other soil and/or groundwater remedial responses. ***Alternative S3A*** (limited removal and off site disposal) will be the most acceptable remedial response to the Community because it will result in the least impact to current and future site use. Implementation of ***Alternative S5A*** (limited removal and on site thermal treatment) and ***Alternative S6*** (limited removal and treatment by soil washing) will result in temporary limitations to use of the Kreher Park during remediation. Implementation of ***Alternative S4*** (limited removal and on site disposal) will result in temporary limitations to use during remediation and permanent limitation to site use following remediation. Implementation of ***Alternatives S3B*** (unlimited removal and off site disposal) and ***Alternative S5B*** (limited removal and incineration) will also result in temporary limitations to use during remediation, but may acceptable to community and regulatory agencies. .

3.0 Groundwater

This section of the Comparative Analysis of Groundwater Alternatives Technical Memorandum is organized as follows:

Section 3.1: Remedial Action Objective for Groundwater
Section 3.2: Potential Remedial Technologies for Groundwater
Section 3.3: Development of Potential Remedial Alternatives for Groundwater
Section 3.4: Evaluation of Potential Remedial Alternatives for Groundwater
Section 3.5: Comparative Analysis of Potential Remedial Alternatives for Groundwater

3.1 Remedial Action Objectives for Groundwater

The general goal of RAOs is to protect human health and environmental receptors at risk from contaminants at the site. These objectives are subject to the criteria evaluated in the Feasibility Study. As described in the RAO Tech Memo (URS 2007) preliminary RAOs for groundwater are as follows:

- Protect human health by eliminating exposure (direct contact, ingestion, inhalation) to groundwater with COPCs in excess of regulatory or risk-based standards; reduce contaminant levels in groundwater to meet MCLs and State of Wisconsin Drinking Water Standards
- Protect the environment by controlling the off site migration of contaminants in groundwater to surrounding surface water bodies which would result in exceedance of ARARs for COPCs in surrounding surface waters.
- Conduct free product removal whenever it is necessary to halt or contain the discharge of a hazardous substance or to minimize the harmful effects of the discharge to the air, land or water.

No COPCs were initially identified in the HHRA for groundwater because groundwater is not used as a potable water supply. However, currently there is no restriction on groundwater use in the area of known contamination. Exposure to contaminated groundwater and accompanying NAPLs can potentially occur via the following exposure scenarios:

- Construction worker exposure to shallow groundwater infiltrating trenches at Kreher Park; and
- Trespasser exposure to groundwater infiltrating the lower level of the former WWTP.

NAPL encountered in the Kreher Park fill, ravine fill, NSPW property and Copper Falls aquifer are a source for the dissolved phase plumes identified in groundwater in each unit at the Site. PRGs for NAPL within these units are based on WAC NR 708.13, which states the following:

> *Responsible parties shall conduct free product removal whenever it is necessary to halt or contain the discharge of a hazardous substance or to minimize the harmful effects of the discharge to the*

air, lands or waters of the state. When required, free product removal shall be conducted, to the maximum extent practicable, in compliance with all of the following requirements:

> **(1)** *Free product removal shall be conducted in a manner that minimizes the spread of contamination into previously uncontaminated zones using recovery and disposal techniques appropriate to the hydrologic conditions at the site or facility, and that properly reuses or treats discharges of recovery byproducts in compliance with applicable state and federal laws.*
> **(2)** *Free product removal systems shall be designed to abate free product migration.*
> **(3)** *Any flammable products shall be handled in a safe and competent manner to prevent fires or explosions.*

Using the above criteria, alternatives for the removal of NAPL will be further refined in the Feasibility Study.

3.2 Potential Remedial Technologies for Groundwater

This section presents a description of remedial technologies retained for additional evaluation based on the results of the Alternatives Screening Technical Memorandum (ASTM) dated April 9, 2007. The following remedial technologies for groundwater were retained for screening, and are described in detail in Section 2.3.

1. No Action
2. Institutional Controls
3. Monitored Natural Attenuation
4. Containment Using Engineered Surface and Vertical Barriers
5. In-situ Treatment Using Ozone Sparging
6. In-situ Treatment Using Surfactant Injection and Removal using Dual Phase Recovery
7. In-situ Treatment Using Permeable Reactive Barrier Walls
8. In-situ Treatment Using Chemical Oxidation
9. In-situ Treatment Using Electrical Resistance Heating
10. In-situ Treatment Using Dynamic Underground Stripping /Steam Injection
11. Removal using Groundwater Extraction Wells

Institutional controls and monitored natural attenuation were not retained for screening as stand alone remedial responses; both technologies were evaluated as elements of other active remedial alternatives for soil and groundwater. Surface barriers, vertical barriers, SVE, and groundwater extraction were combined with other potential remedial technologies for groundwater as described below.

3.3 Development of Potential Remedial Alternatives for Groundwater

Groundwater remedial technologies retained for screening were used to develop potential remedial alternatives for groundwater. Remedial alternatives for groundwater presented in this report are summarized in Table 3-1. A description of each remedial alternative follows.

3.3.1 Alternative GW1 - No Action

The "no action" alternative for groundwater was retained as required by the NCP as a basis for comparing the other alternatives. The NCP at Title 40 Code of Federal Regulations (40 CFR §300.430(e)(6)) provides that the no-action alternative should be considered at every site. Implementation of no further action consists of leaving contaminated groundwater in place; no engineering, maintenance, or monitoring will be required.

3.3.2 Alternative GW2 -Containment Using Engineered Surface and Vertical Barriers

Containment for groundwater contamination consists of the utilization of natural or man-made barriers to prevent potential exposure to or migration of contaminants with subsurface contamination. Containment alternatives retained for screening and evaluated in this report include engineered surface barriers, vertical barrier walls installed in the aquifer, and extraction wells (barrier wells). Surface barriers eliminate the direct contact exposure pathway and reduce contaminant leaching from the unsaturated zone, by restricting infiltrating water from contacting contaminated soil. Vertical barrier walls and barrier wells prevent the off site migration of contaminants. Engineered surface barriers, vertical barrier walls, and barrier wells are described below.

Engineered Surface Barrier

Engineered surface barriers are considered passive containment alternatives because the contaminated zone is not disturbed, and only minimal maintenance is required following implementation. Surface barriers include the following:

- Asphalt cap;
- Low permeability soil cap (i.e. 2 feet of clay with hydraulic conductivity of less than 10^{-7} cm/sec) cap;
- Multi-layer cap with a minimum two-foot thick clay barrier, drainage layer, soil and vegetated top soil cover; and,
- Multi-layer cap with geomembrane (a minimum two-foot thick clay barrier, geomembrane, drainage layer, soil and vegetated top soil cover.

At the upper bluff area, asphalt caps over the filled ravine as surface barriers will be compatible with existing and future site use. At Kreher Park, asphalt pavement for the marina parking lot and a low permeability cap for the former coal tar dump will be compatible with existing and future site use. Multi-layer caps will be compatible with on site and off site disposal options for soil and the CDF for sediment. Multi-layer cap will also be compatible with areas area of unexcavated soil, especially in Kreher Park. Single layer asphalt and low permeability caps will satisfy at a minimum 40 CFR Subtitle D requirements, and multi-layer caps will satisfy 40 CFR Subtitle C requirements. As with potential soil remedial alternatives (evaluated in section 2.3), surface barriers will be included as key elements of the potential groundwater and sediment remedial alternatives.

Barrier Wells

Barrier wells are considered active containment alternatives because long-term operation (groundwater extraction), maintenance, and monitoring will be required. Down gradient barrier wells were retained for groundwater at the upper bluff and for the saturated fill unit at Kreher Park. Properly engineered, these wells will prevent contaminants from migrating off site with groundwater. However, down gradient barrier wells were not considered for the Copper Falls aquifer. Regional groundwater flow conditions in the Copper Falls indicate that a stagnation zone beneath the center of Kreher Park has prevented the dissolved phase plume from migrating beyond the shoreline. Additional hydrogeologic and groundwater quality data will be required to ensure that contaminants will not migrate beyond the Kreher Park shoreline.

Well EW-4 was installed at the mouth of the filled ravine to prevent water discharging to the seep area at Kreher Park; it has been in operation since 2002. A final remedy for shallow groundwater in the ravine could include continued operation of EW-4, installation of additional extraction wells, or future operation of EW-4 along with a vertical barrier wall installed down gradient from the extraction well (use of EW-4 will reduce the hydraulic head behind the vertical barrier). An evaluation of the volume of groundwater discharging from the filled ravine and a capture zone analysis for EW-4 will be necessary to evaluate which alternative will be more effective. Continued use of EW-4 as a barrier well for the upper bluff, and barrier wells for shallow groundwater at Kreher Park are evaluated with Alternative GW-9 (removal using groundwater extraction).

Vertical Barrier Walls

Vertical barrier walls are also considered active containment alternatives because contaminated material may be disturbed during construction, and/or long-term maintenance such as groundwater extraction may be required. Engineered vertical barrier walls were retained for further evaluation as potential containment alternatives for shallow contaminated groundwater encountered in the ravine fill at the upper bluff and at Kreher Park. However, vertical barrier walls would not be feasible for the underlying Copper Falls aquifer because this deep aquifer is confined by the Miller Creek formation creating strong upward gradients. Installation of a barrier wall for contaminants in the Copper Falls aquifer will require penetration of the Miller Creek, formation which will likely compromise the long-term integrity of this confining unit.

Vertical barriers walls consist of a slurry wall or sheet piling installed around the perimeter of the contaminated groundwater zone. A slurry wall is a low permeability barrier constructed by placing a low permeability material (slurry) in a trench around the perimeter of the contaminated groundwater mass. Sheet piling consisting of inter-locking sheets of steel pilings form a continuous wall installed around the perimeter of the contaminated groundwater mass. Both types of vertical barriers can be anchored into the underlying low permeability Miller Creek Formation to create a barrier that will prevent contaminants in the shallow fill units from migrating off site with groundwater.

In additional to vertical barriers, the Feasibility Study will evaluate the use of engineered surface barrier to minimize infiltration versus the installation of a multi layer cap for contained areas. Although a multi-layer cap will result in significant site disturbance and additional implementation cost, long-term operation, maintenance, and monitoring cost will likely be lower[8]. For Kreher Park, this alternative may be used in combination with containment alternatives evaluated for nearshore sediment described in Section 4.0. The location of the vertical barrier wall at Kreher Park is shown on Figure 3-1. Key elements for the conceptual design of a sheet pile vertical barrier wall around the perimeter of Kreher Park follows:

1. Site preparation will include clearing and grubbing of small trees and bushes along the bluff and near the former seep area as needed.
2. Although the former waste-water treatment plant will be located within the contained area, demolition of this dormant facility may be required.
3. A vertical barrier wall will be placed around the perimeter of Kreher Park. This vertical barrier will consist of a sheet pile wall anchored into the underlying Miller Creek Formation.
4. The sheet pile wall along the shoreline will be installed at an approximate depth of 25 feet below existing grade to allow the off-shore removal of sediment to a depth of ten feet. The sheet pile wall on the south, east, and west sides of the Park will be installed at an approximate depth of 16 feet below existing grade.
5. Surface barriers will be installed over the filled ravine to minimize infiltration, and the sheet pile wall on the south side of Kreher Park will terminate on the east and west flanks of the filled ravine to create a “funnel” for shallow groundwater discharge into Kreher Park[9].
6. A groundwater diversion trench will be installed between the remainder of the south wall and the upper bluff area to divert groundwater that currently seeps into the Kreher Park fill unit.

[8] Groundwater recharge at Kreher Park results from seepage from the upper bluff area and infiltration. Although groundwater from the upper bluff area can be diverted, infiltration seeping into the confined area may still increase the hydraulic head within the confined area. Surface barrier placed over the marina parking lot and former coal tar dump area will reduce infiltration, and storm water control features can be constructed to promote run-off. However, long-term groundwater extraction may be needed to reduce the hydraulic head within the contained area.

[9] For the upper bluff area, a vertical barrier wall at the mouth of the filled ravine, which may require groundwater extraction, or this installation of a permeable reactive barrier wall (PRB). These groundwater treatment alternatives will also be evaluated in the Feasibility Study. A PRB is evaluated as Alternative GW-5, and a barrier well for the filled ravine is evaluated as Alternative GW-9 (removal and groundwater extraction) in this report.

7. At Kreher Park, site restoration will include installation of new asphalt pavement over the marina parking lot to minimize infiltration in this area. Additionally, a low permeability soil cap will be placed over the former coal tar dump area, and if applicable, a soil cap over the disposal cell. [10].
8. Regrading and a storm-water basin will be constructed within the confined area to manage storm-water and restrict infiltration.
9. Long-term operation and maintenance of the facility will include the removal of contaminated groundwater. A minimum of 15 pressure relief wells will be installed to periodically remove groundwater and reduce the hydraulic head within the confined area[11].

Long-term operation and maintenance will include groundwater monitoring to evaluate the effectiveness of the vertical barrier walls. Fluid levels will also be monitored to ensure the hydraulic head within the confined area remains below lake level. Institutional controls will likely be implemented as a part of this remedial response.

3.3.3 Alternative GW3 - In-situ Treatment Using Ozone Sparging

Ozone sparging is an in-situ chemical oxidation technology that can be used to oxidize and degrade contaminants in groundwater. Because ozone is a gas, it can be injected into the saturated zone as a gas via sparging. Sparging consists of injecting air or oxygen rich ozone into an aquifer as a gas through small diameter sparge wells. Commercially, ozone is generated by a high voltage discharge through air or oxygen in an ozone generator. Generally, yields are on the order of 1 to 3-percent ozone by volume in air and 2 to 6-percent ozone by volume in oxygen. In water, ozone decomposes to form free radicals. These free radicals are strong oxidizers and react with contaminants in water to form carbon dioxide and water. As an additional benefit, ozone treatment increases the dissolved oxygen level in the water when any unreacted free radicals combine to form water and oxygen; the dissolved oxygen content in groundwater promotes biodegradation of contaminants.

Ozone sparging is typically used for dissolved phase contamination, but is typically not used in areas where NAPL is present. If used for NAPL contamination, groundwater extraction will likely be needed because ozone/air injection may displace NAPL and/or cause a chemical reaction increasing the mobility of NAPL. This mobilized material is then recovered via extraction wells. Air/ozone sparging was retained for further evaluation as a potential in-situ treatment alternative for contaminated groundwater encountered in the underlying Copper Falls aquifer. Although this technology can also be used for contaminated shallow groundwater in the ravine fill and at Kreher Park, buried structures (the former gas holders) and man made debris (wood waste, bricks, cinders, etc.) may prevent proper installation of sparge wells to allow

[10] A multi-layer cap over the remainder of Kreher Park would also reduce infiltration, and will be evaluated in the Feasibility Study.

[11] The Feasibility Study will also include an evaluation of on- and off site treatment and disposal of extracted groundwater, which will be determined by the anticipated volume of groundwater to be extracted.

optimum delivery. Additionally, injecting into fill soil, which exhibits a wide range of physical characteristics (permeability in particular), may limit the effectiveness of this in-situ technology. The layout of an ozone sparge system for underlying the Copper Falls Aquifer is shown on Figure 3-2. Key elements for the conceptual design of an ozone sparging system for shallow groundwater at the upper bluff area and at Kreher Park, and for the Copper Falls Aquifer follows:

1. All sparge wells will be installed in soil borings advanced with a hollow stem auger by a rotary drill rig.
2. Sparge wells will be installed on approximate 50-foot diameter centers, and one control panel will inject ozone into a cluster of 12 sparge wells. A pilot test will be necessary to obtain information for designing of the sparge well system.
3. One control panel will be needed for shallow groundwater in the filled ravine.
4. Eight control panels will be needed for shallow groundwater at Kreher Park.
5. Six control panels will be needed for groundwater in the underlying Copper Falls aquifer.
6. All air lines between the sparge wells and control panels will be buried in shallow trenches.
7. For the Copper Falls aquifer, the existing groundwater extraction system will likely be operated concurrent with the ozone sparge system to recover NAPL.

The ozone sparge system may need to be operated for several years, and long-term groundwater monitoring will be required to evaluate the effectiveness of the sparging and subsequent natural attenuation. Institutional controls will also be utilized for this option.

3.3.4 Alternative GW4 - In-situ Treatment using Surfactant Injection and Dual Phase Recovery

Physical/chemical treatment includes the use of surfactants to enhance the removal of NAPL. Surfactant injection is an in-situ injection technology. Surfactants are “surface active agents” that reduce the interfacial tension between oil (NAPL) and water by adsorbing at the liquid-liquid interface, which can result in an increase in the mobility of NAPL. Injection can also displace oil trapped within the aquifer media. Groundwater remediation using surfactant is a two phase approach involving injection of surfactant and recovery of fluids. Surfactant is injected to displace or mobilize NAPL, which is then recovered slowly by groundwater extraction or rapidly by vacuum enhancement. Vacuum enhancement is also referred to as dual phase or multiphase extraction because an induced vacuum is used to remove air, water, and NAPL simultaneously.

For the Copper Fall Aquifer, dual phase recovery was retained for screening. Although this technology can also be applied to contaminated groundwater in the ravine fill and at Kreher Park, site conditions may prevent implementation and limit effectiveness. Buried structures (the former gas holders) and man made debris (wood waste, bricks, cinders, etc.) may prevent proper installation of injection/extraction wells. Additionally, fill soil, which exhibits a wide range of physical characteristics (permeability in particular), may limit the effectiveness of this in-situ technology. The layout of injection/extraction wells for the underlying Copper Falls Aquifer is shown on Figure 3-3. Key elements for the conceptual design of surfactant injection and dual phase recovery system the Copper Falls Aquifer follows:

1. A minimum of 30 small diameter injection/extraction wells will be installed in borings advanced below the Miller Creek / Copper Falls interface where NAPL has been identified. (Existing piezometers in this area will also be utilized).
2. Each well will be constructed with 2-inch diameter SCH 80 PVC well casing and screen. A sand pack will be placed around a well screen five feet in length.
3. Surfactant will be injected into wells where NAPL has been encountered to lower the interfacial tension that restricts the movement of non-mobile NAPL in the aquifer.
4. After allowing the surfactant to penetrate the formation for 24 to 48 hours, NAPL and groundwater is then removed by an induced vacuum and treated on site. Fluids will be removed from the injection/extraction wells by vacuum enhancement. To remove a significant mass of mobile NAPL, it is assumed that fluids will be removed monthly for one year before the next application is injected.
5. Multiple applications will be needed to remove NAPL to the extent practicable; for this evaluation it is assumed that a minimum of five applications of surfactant will be needed. Recovered fluids will be treated on site prior to discharge to the sanitary sewer. This will require upgrades to the existing treatment system.
6. A pilot test using existing piezometers MW-2AR, MW-4A, MW-10B, MW-13A, MW-15A, MW-19A, MW-21A, and MW-22A screened at the Miller Creek / Copper Falls interface should be completed prior to full scale remediation to determine if a mobile vacuum truck or fixed based system is needed for dual phase recovery. The pilot test will also be used to evaluate, the mobile mass of NAPL that can be removed, the number of applications needed, and the most efficient frequency of fluid removal between injections.

Surfactant injection and dual phase recovery can likely be completed within one year, but the existing groundwater remediation system may need to be operated for several more years. Long-term groundwater monitoring will be required to evaluate natural attenuation and institutional controls will be implemented as part of this option.

3.3.5 Alternative GW5 - In-situ Treatment using Permeable Reactive Barrier Walls

Physical/chemical treatment also includes the use permeable reactive barrier (PRB) walls to treat contaminated groundwater migrating from source areas. PRB walls are limited to subsurface conditions where contaminants are bound within a continuous aquitard at a depth within the vertical limits of trenching equipment. PRB walls are installed across the flow path of a contaminant plume, allowing the water portion of the plume to passively move through the wall. There are two types of barriers, 1) permeable reactive barriers and 2) in-place bioreactors. These barriers allow the passage of water while restricting, via reaction with barrier materials, the movement of contaminants. Contaminants are either degraded, adsorbed, or retained in a by the barrier material. Vertical barriers will prevent seepage into Kreher Park from the lake and upper bluff areas. However, groundwater may still be recharged by infiltration. Shallow groundwater will be allowed to discharge from Kreher Park through the PRB wall. PRB walls are passive system designed for long-term operation to control treat contaminants migrating from source areas with ground water.

PRB walls were not retained for the underlying Copper Falls Aquifer as construction of the PRB would require penetration of the overlying Miller Creek Formation. The Miller Creek forms a confining unit for the Copper Falls Aquifer, which has strong upward gradients at the Site, and construction will compromise the integrity of the confining unit. However, a PRB could be used as a remedial alternative for shallow groundwater. Instead of installing PRB walls in source areas, they are typically installed at down gradient locations to treat contaminated groundwater before is migrates off site. PRB walls are more expensive than vertical barrier walls. PRB walls are typically constructed as “gate” and “funnel” systems; gates are vertical barriers used to direct groundwater flow to the PRB wall which functions as a funnel and treats groundwater before it leaves the site. A sheet pile or slurry wall (vertical barrier) will be installed around the east, north, and south sides of Kreher Park to form the gate, and a down gradient PRB will be installed along the west side as the funnel. The layout of the PRB wall, vertical barrier wall, and engineered surface barrier is shown on Figure 3-4. Key elements for the conceptual design of a PRB wall for shallow groundwater at the site follow:

1. Site preparation will include clearing and grubbing of small trees and bushes along the bluff and near the former seep area as needed.
2. Although the former waste-water treatment plant will be located within the contained area, demolition of this dormant facility may still be required as part of the overall remediation to accommodate future site use.
3. A vertical barrier wall will be placed on the north, east, and south sides of Kreher Park. This vertical barrier will consist of a sheet pile wall anchored into the underlying Miller Creek Formation.
4. The sheet pile wall along the shoreline will be installed at an approximate depth of 25 feet below existing grade to allow the off-shore removal of sediment to a depth of ten feet. The sheet pile wall on the south, east, and west sides of the Kreher Park will be installed at an approximate depth of 16 feet below existing grade.
5. A trench will be excavated on the west side of the Kreher Park for the PRB wall. The wall will be constructed with a porous layer of granular activated carbon to remove dissolved phase organic compounds prior to discharge.
6. Surface barriers will be installed over the filled ravine to minimize infiltration, and the sheet pile wall on the south side of Kreher Park will terminate on the east and west flanks of the filled ravine to create a “funnel” for shallow groundwater discharge into Kreher Park[12].
7. A groundwater diversion trench will be installed between the remainder of the south wall and the upper bluff area to divert groundwater seepage into the Kreher Park fill unit.

[12] For the upper bluff area, a PRB wall at the mouth of the filled ravine will also be evaluated in the Feasibility Study.

8. Site restoration will include installation of new asphalt pavement over the marina parking lot and a low permeability soil cap over the disposal cell and former coal tar dump area to minimize potential exposure to subsurface contamination and minimize infiltration[13].
9 Regrading and a storm-water basin will be constructed within the confined area to manage storm-water and restrict infiltration.

Long-term operation and maintenance of the facility will include groundwater monitoring to evaluate the effectiveness of the PRB. Reactive material used to construct the PRB may need to be replaced if NAPL migrates from the source area and permeates the PRB. Fluid levels will also be monitored to ensure the hydraulic head within the confined area remains below lake level. Institutional controls will likely be implemented as part of this remedial option.

3.3.6 Alternative GW6 – Treatment using Chemical Oxidation

Chemical oxidation introduces strong oxidizing chemicals such as permanganate and peroxide into the subsurface to degrade VOCs and PAH compounds to CO_2 and H_2O end products. Permanganate or peroxide could be injected as liquid reagents through boreholes, wells, or mixed with a backhoe in shallow trenches. Chemical oxidation has an added benefit of enhancing biodegradation by increasing oxygen concentrations in the subsurface. Chemical oxidation could be performed on saturated and unsaturated zone soils by injecting chemicals into the subsurface via borings or wells.

In-situ chemical oxidation could be used for unsaturated and saturated zone contamination at the upper bluff. However, existing conditions at the upper bluff area (the NSPW facility building and buried gas holders) and at Kreher Park (wood waste layer) may limit implementability. Mixing reagent in shallow trenches would be the most effective treatment method at Kreher Park because contamination is present at shallow depths at the former coal tar dump area, and would be easily accessible. Because in-situ chemical oxidation reactions can result in the generation of off-gases, primarily $CO_{2,}$ passive venting or an active SVE system may be required to capture off-gases. The presence of NAPL may require multiple applications to lower contaminant concentrations to acceptable levels. Potential injection locations for in-situ chemical oxidation at the upper bluff area are shown on Figure 3-5A. Key elements for the conceptual design for in-situ chemical oxidation for shallow soil and groundwater at the site follow:

1. Demolition of the center section of the NSPW service center south of St. Claire Street will be required to access contaminated soil beneath the building at the upper bluff area.
2. Replacement of existing asphalt pavement south of St. Claire Street and new pavement north of St. Claire Street will be required.
3. Between 200 and 300 injection borings will be advanced in the filled ravine using a direct push drill rig[14].

[13] A multi-layer cap would also reduce infiltration, and will be evaluated in the Feasibility Study.

[14] Direct use was used to advance injection boring for the USEPA SITE pilot test completed at the Site in early 2007.

4. For this evaluation it is assumed that approximately 1,500 gallons of reagent will be injected into each boring.
5. A minimum of 10 passive vent wells will be installed in the filled ravine.
6. Site preparation will include clearing and grubbing small trees and bushes along the bluff and near the former seep area as needed at Kreher Park
7. Chemical oxidation at Kreher Park will be completed above the wood waste layer in the former coal tar dump area by mixing reagent in a shallow excavation.
8. Site restoration will include installation of new asphalt pavement over the marina parking lot and a low permeability soil cap over the former coal tar dump area to minimize potential exposure to subsurface contamination and minimize infiltration.
9. Regrading and a storm-water basin will be constructed within the confined area to manage storm-water and restrict infiltration.
10. Multiple applications may be needed to reduce contaminant levels to the extent practicable.

Implementation for the underlying Copper Falls would be more extensive; it may require groundwater extraction rather than soil vapor extraction. The USEPA's SITE program recently completed a demonstration pilot test to fully evaluate the implementability of this alternative at the Site. Additional data will be available in the near future following compilation of pilot test data. Chemical oxidation may also increase the mobility of NAPL recovered by extraction wells resulting in the removal of significant contaminant mass in a short time frame. Preliminary results from the recent SITE program pilot test indicate that injection into areas with NAPL contaminants resulted in an initial vigorous reaction followed by an increase in the mobility and recovery of NAPL. Additional data is currently being collected and will be available in the near future to evaluate NAPL recovery and improvements to groundwater quality. Potential injection locations for in-situ chemical oxidation for the underlying Copper Falls aquifer are shown on Figure 3-5B. Key elements for the conceptual design for in-situ chemical oxidation for the Copper Falls aquifer follow:

1. Between 250 and 500 injection borings will be advanced in the Copper Falls aquifer using a direct push drill rig.
2. For this evaluation it is assumed that approximately 1,500 gallons of reagent will be injected into each boring.
3. Existing extraction wells EW-1, EW-2, and EW-3 will continue to operate during and after reagent injection.
4. A minimum of 7 additional extraction wells will be installed in the Copper Falls aquifer in borings advanced with hollow stem auger using a rotary drill rig.
5. Recovered fluids will be treated on site prior to discharge to the sanitary sewer. This will require upgrades to the existing treatment system.
6. Multiple applications may be needed to reduce contaminant levels to the extent practicable.

Although chemical oxidation applications can be completed within a short period of time, the groundwater extraction system may be operated for several years. Long-term groundwater monitoring to evaluate natural attenuation and institutional controls will be included with this remedial response.

3.3.7 Alternative GW7 - In-situ Treatment using Electrical Resistance Heating

Electrical resistance heating (ERH) technology uses electricity applied into the ground through electrodes to heat the formation. This mobilizes contaminants by heating contaminants and groundwater to boiling point, the steam and contaminants are then recovered with a SVE, groundwater extraction, or dual phase system. The ERH electrodes can be installed either vertically to about 100 feet or horizontally beneath buildings. ERH heats the contaminants up to 100 ^{0}C, which raises the vapor pressure of volatile and semi-volatile organic compounds in the soil. For soil and shallow groundwater, this enhances the recovery of volatilized contaminants by SVE. At these high temperatures (100 ^{0}C), ERH can also be used to dry soil, which can create fractures that increase soil permeability resulting in improved recovery of contaminants by SVE. At high temperatures, saturated zone soils can also be heated to high temperatures to create steam that strips contaminants from soil. Treatment of effluent vapors and dissolved phase groundwater contamination will be required before discharge of air and/or water.

Implementation of this technology for shallow soil and groundwater contamination could be completed simultaneously; SVE and groundwater extraction will likely be required. Existing site buildings and buried structures at the upper bluff and the wood waste layer at Kreher Park will likely limit implementation of this alternative for soil and shallow groundwater. If a containment alternative is implemented for Kreher Park, treatment of shallow soil and groundwater will not be required. If removal of buried structures is required, ERH may not be as feasible for soil and shallow groundwater as are removal and ex-situ treatment alternatives described in Section 2.0. Building demolition and removal of the buried structures at the upper bluff area would enhance the implementability of ERH for the underlying Copper Falls aquifer. For shallow soil and groundwater at the upper bluff area and at Kreher Park, and for the underlying Copper Falls aquifer, ERH could be utilized with groundwater extraction to remove NAPL. Rather than heat soils to create steam, the saturated zone is heated to between 30oC and 40oC to decrease the viscosity and increase the mobility of NAPL, which is then removed via extraction wells or by a dual phase recovery system. Current Environmental Solutions (CES) reported over 5,000 gallons of product was recovered after the first three months of operation at a former MGP site in Illinois (*Enhanced Free Product Recovery Using Low Temerature In-Situ Heating - An Option For MGP Sites*, CES 2006).

Potential locations for ERH electrodes, SVE, and extraction well for shallow soil and groundwater at the upper bluff area are shown on Figure 3-6A. Key elements for the conceptual design for ERH for shallow soil and groundwater at the site follow:

1. Demolition of the center section of the NSPW service center south of St. Claire Street will be required to access contaminated soil beneath the building in the upper bluff area.

2. Replacement of existing asphalt pavement south of St. Claire Street and new pavement north of St. Claire Street will be required.
3. Installation of a minimum of 200 electrodes in the filled ravine and 150 electrodes in the former coal tar dump area to heat the subsurface.
4. A minimum of 10 passive vent wells will be installed in each area
5. A minimum of 4 additional extraction wells will be installed in each area.
6. Effluent vapors and dissolved phase groundwater contamination will be required before discharge of air and/or water. Vapor-phase carbon adsorption will be used to treat vapors prior to discharge to the atmosphere. Water will be treated by the on site treatment system prior to discharge to the sanitary sewer; this will require upgrades to the existing treatment system.
7. Site preparation will include clearing and grubbing of small trees and bushes along the bluff and near the former seep area as needed at Kreher Park.
8. Site restoration will include installation of new asphalt pavement over the marina parking lot and a low permeability soil cap over the disposal cell and former coal tar dump area to minimize potential exposure to subsurface contamination and minimize infiltration.
9. Regrading and a storm-water basin will be constructed within the confined area to manage storm-water and restrict infiltration.

Potential injection locations for ERH electrodes and SVE wells for deep groundwater contamination in the Copper Falls Aquifer are shown on Figure 3-6B. Key elements for the conceptual design for ERH for shallow the Copper Falls aquifer follow.

1. Demolition of the center section of the NSPW service center will be required to access the underlying Copper Falls Aquifer.
2. Removal of the buried gas holders will improve the implementability of ERH for the underlying Copper Falls Aquifer.
3. Installation of a minimum of 200 electrodes in the underlying Copper Falls Aquifer to heat the subsurface.
4. A minimum of 12 additional extraction wells will be installed in each area.
5. Effluent vapors and dissolved phase groundwater contamination will be required before discharge of air and/or water. Vapor-phase carbon adsorption will be used to treat vapors prior to discharge to the atmosphere. Water will be treated by the on site treatment system prior to discharge to the sanitary sewer; this will require upgrades to the existing treatment system.

Although ERH can be completed within a short period of time, the groundwater extraction system may be operated for several years. Long-term groundwater monitoring to evaluate natural attenuation and institutional controls will be included with this remedial response.

3.3.8 Alternative GW8 - In-situ Treatment using Steam Injection / Dynamic Underground Stripping / Contained Recovery of Oily Wastes (CROW) Process

Steam injection physically separates volatile and semi-volatile organic constituents from soil by thermal or mechanical energies. A passive or active SVE and/or groundwater extraction system will be needed to recover volatilized contaminants. Implementation for soil and shallow groundwater remediation can be completed simultaneously. Potential steam injection and recovery wells for shallow soil and groundwater at the upper bluff are shown on Figure 3-7A. (A similar array would be utilized for contained recovery of oily wastes.)

Key elements for the conceptual design for steam injection for shallow groundwater follow.

1. Demolition of the center section of the NSPW service center south of St. Claire Street will be required to access contaminated soil beneath the building in the upper bluff area.
2. Replacement of existing asphalt pavement south of St. Claire Street and new pavement north of St. Claire Street will be required.
3. Installation of a boiler for generation of steam for injection.
4. A minimum of four steam recovery wells will be installed at each area (the filled ravine and the former coal tar dump area).
5. A minimum of seven recovery wells will be installed in the filled ravine, and five recovery wells will be installed at Kreher Park.
6. Effluent vapors and dissolved phase groundwater contamination will be required before discharge of air and/or water. Vapor phase carbon will be used to treat vapors prior to discharge to the atmosphere. Water will be treated by the on site treatment system prior to discharge to the sanitary sewer; this will require upgrades to the existing treatment system.
7. Site preparation will include clearing and grubbing of small trees and bushes along the bluff and near the former seep area as needed at Kreher Park as needed.
8. Site restoration will include installation of new asphalt pavement over the marina parking lot and a low permeability soil cap over the disposal cell and former coal tar dump area to minimize potential exposure to subsurface contamination and minimize infiltration.
9. Regrading and a storm-water basin will be constructed within the confined area to manage storm-water and reduce infiltration.

Implementation for the underlying Copper Falls aquifer will require groundwater extraction and treatment of contaminated fluids mobilized by heating via a hybrid steam injection process called Dynamic Underground Stripping (DUS). DUS is a combination of technologies. DUS consists of the following integrated technologies: steam injection; electrical heating; underground imaging; and collection and treatment of effluent vapors, NAPL, and contaminated groundwater. These technologies are utilized as follows:

- Steam injection at the periphery of the contaminated area heating permeable zone soils, which then vaporizes volatile compounds bound to the soil causing contaminant migration to centrally located vapor/groundwater extraction wells;
- Electrical heating of less permeable clays and fine-grained sediments vaporizing contaminants causing migration into the steam zone;

- Underground imaging, primarily Electrical Resistance Tomography (ERT) and temperature monitoring, which delineates the heated area and tracks the steam fronts daily to monitor cleanup, and
- Treating effluent vapors, NAPL, and impacted groundwater as needed before discharge.

Hydrous Pyrolysis/Oxidation (HPO) is a process sometimes completed after contaminants are removed during the DUS phase. HPO consists of steam and air injection, which creates a heated, oxygenated zone in the subsurface. After the injection is terminated the steam condenses causing contaminated groundwater to migrate to the heated zone where it mixes with the condensed steam and oxygen. Although this may destroy some microorganisms impeding natural biodegradation, HPO enhances biodegradation of residual contaminants by stimulating other microorganisms (called thermophiles) that thrive at high temperatures. A pilot test will be needed to evaluate the effectiveness of HPO after DUS.

Potential steam injection and recovery wells for deep groundwater contamination in the Copper Falls aquifer are shown on Figure 3-7B. Key elements for the conceptual design for DUS for the Copper Falls Aquifer follow.

1. Demolition of the center section of the NSPW service center south of St. Claire Street will be required to access the underlying Copper Falls Aquifer at the upper bluff area.
2. A minimum of 12 steam injection wells will be installed in the Copper Falls Aquifer at the upper bluff area.
3. A minimum of 9 recovery wells will be installed in the Copper Falls Aquifer at the upper bluff area.
4. Recovered fluids will be treated on site prior to discharge to the sanitary sewer. This will require upgrades to the existing treatment system.

Although steam injection or DUS can be completed within a short period of time, the groundwater extraction system may be operated for several years. Long-term groundwater monitoring will be required to evaluate natural attenuation and institutional controls as final remedial responses.

Another in situ technology using thermal injection is the Contained Recovery of Oily Wastes (CROW) process. Rather than steam, injection wells utilizing hot water displace NAPL toward recovery wells, which then convey the mixture to separators along with an on site treatment system. This innovative technology has been successfully used at tar sites as full-scale remedial applications. Limitations to the technology include groundwater injection and recharge, groundwater chemistry, site accessibility, and utility access.

For purposes of this comparison, the conceptual design layouts discussed above for steam injection will be similar. A pilot test will likely be necessary prior to a full application at the Ashland Site. Information developed for the 2006-2007 SITE ISCO demonstration (injection rates, aquifer chemistry where applicable) will be utilized in the full analyses of this option in the Feasibility Study.

3.3.9 Alternative GW9 – NAPL Removal using Groundwater Extraction Wells

Groundwater extraction uses water as a carrier to remove both NAPL and dissolved phase contamination. Groundwater extraction can be implemented for shallow groundwater contamination encountered at the upper bluff area and Kreher Park as well as the underlying Copper Falls Aquifer. The existing groundwater extraction interim system currently extracts groundwater from one well installed at the mouth of the filled ravine, and groundwater and NAPL from three low flow wells installed in the underlying Copper Falls Aquifer. Enhanced removal at the upper bluff area will include installation of additional low flow extraction wells in the Copper Falls aquifer to increase NAPL removal rates, and continued operation of existing wells EW-1, EW-2, and EW-3. This will also include continued operation of EW-4. However, an evaluation of the volume of groundwater discharged from the filled ravine along with a capture zone analysis for this well will also be required to evaluate utilization of EW-4 for shallow groundwater containment (i.e. barrier wells, or to reduce hydraulic head behind a vertical barrier wall). Potential extraction well locations for the Copper Falls aquifer are shown on Figure 3-8A. Key elements for enhanced groundwater and NAPL extraction in the upper bluff area follow.

1. A minimum of 12 extraction wells will be installed in the Copper Falls Aquifer.
2. Installation of lateral piping between each extraction well and the existing treatment building.
3. Replacement of existing asphalt pavement south of St. Claire Street and new pavement north of St. Claire Street will be installed to reduce infiltration into the ravine fill.
4. Recovered fluids will be treated on site prior to discharge to the sanitary sewer. This will require upgrades to the existing treatment system.

Horizontal rather than vertical extraction wells will be used at Kreher Park because shallow groundwater is encountered in a widespread thin fill unit, and fill material has variable permeability in this area. A potential horizontal well configuration for shallow groundwater extraction contamination at Kreher Park is shown on Figure 3-8B. Key elements for the conceptual design for shallow groundwater extraction at Kreher Park follow.

1. Horizontal wells consisting of perforated pipe will be installed in trenches penetrating the saturated fill unit[15].
2. One trench will transcend the length of the Kreher Park. Lateral trenches will be installed to dissect the former coal tar dump area and the former open sewer area.
3. Recovered fluids will be treated on site prior to discharge to the sanitary sewer. This will require installation of a treatment system at Kreher Park

[15] The Feasibility Study will include an evaluation of groundwater extraction with and without vertical barrier walls.

4. Site restoration will include installation of new asphalt pavement over the marina parking lot and a low permeability soil cap over the former coal tar dump area to prevent potential exposure to subsurface contamination and minimize infiltration.

The groundwater extraction system in the upper bluff area and Kreher Park may be operated for an extended period of time. Long-term groundwater monitoring will be required to evaluate natural attenuation and institutional controls will also be implemented as part of this option.

Table 3-1.Summary of Potential Groundwater Remedial Alternatives

Alternative	Upper Bluff Area	Kreher Park	Copper Falls Aquifer	Other Groundwater Remedial Technologies Used
Alternative GW1 No Action	• No removal or treatment of groundwater required.	• No removal or treatment of groundwater required.	• No removal or treatment of groundwater required.	• Not applicable
Alternative GW2 Containment Using Engineered Surface and Vertical Barriers	• Install barrier well or barrier wall at mouth of filled ravine to prevent off site migration of contaminants with groundwater. • Install asphalt pavement as surface barrier over filled ravine.	• Install barrier wall around perimeter of Kreher Park fill to prevent off site migration of contaminants with groundwater. • Install asphalt pavement over marina parking lot, and low permeability soil cap in the former coal tar dump area.	• Not evaluated because installation of a vertical barrier wall may jeopardize the integrity of the overlying confining unit.	• Monitored natural attenuation • Institutional controls • Groundwater extraction
Alternative GW3 In-situ Treatment using Ozone Sparging	• Install sparge wells in the filled ravine south of St. Claire Street.	• Install sparge wells in entire Kreher Park.	• Install of sparge wells in the impacted portion of Copper Falls Aquifer. • Continue to operate existing groundwater remediation system to collect NAPL.	• Monitored natural attenuation • Institutional controls • Groundwater extraction
Alternative GW4 In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery	• Not evaluated because existing conditions (buried gas holders) may impede effectiveness.	• Not evaluated because existing conditions (wood waste layer) may impede effectiveness.	• Install a minimum of 30 injection/extraction wells, inject surfactant, and remove fluid monthly for a minimum of one year.	• Monitored natural attenuation • Institutional controls • Groundwater extraction
Alternative GW5 In-situ Treatment using Permeable Reactive Barrier Walls	• Groundwater from ravine would continue to discharge to Kreher Park where PRB wall will be installed.	• Install PRB wall constructed of GAC on west side of Kreher Park. • Install vertical barrier wall on north, south, and west sides.	• Not evaluated because installation of a PRB wall may jeopardize the integrity of the overlying confining unit.	• Monitored natural attenuation • Institutional controls • Containment using surface and vertical barrier walls
Alternative GW6 In-situ Treatment using Chemical Oxidation	• Inject reagent through borings advanced into filled ravine south of St. Claire Street. • Install a passive SVE system to vent off-gases. • Modify existing treatment system, and treat recovered fluid on site.	• Mix reagent in shallow trench excavated at former coal tar dump area. Would be limited to contamination above the wood waste layer.	• Inject reagent through borings advanced into the underlying Copper Falls Aquifer. • Install additional groundwater extraction wells to collect NAPL. • Modify existing treatment system, and treat recovered fluid on site.	• Monitored natural attenuation • Institutional controls • Soil vapor extraction • Groundwater extraction • Containment using surface and vertical barrier walls

Table 3-1.Summary of Potential Groundwater Remedial Alternatives

Alternative	Upper Bluff Area	Kreher Park	Copper Falls Aquifer	Other Groundwater Remedial Technologies Used
Alternative GW7 In-situ Treatment using Electrical Resistance Heating	• Install array of electrodes in filled ravine to heat subsurface and enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Install array of electrodes above wood waste layer at the former coal tar dump area to heat subsurface and enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Install array of electrodes in the underlying Copper Falls Aquifer to enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Monitored natural attenuation • Institutional controls • Soil vapor extraction • Groundwater extraction • Dual Phase Recovery • Treat air stream from SVE prior to discharge. • Treatment of SVE condensate prior to discharge. • Containment using surface and vertical barrier walls
Alternative GW8 In-situ Treatment using Dynamic Underground Stripping (Steam Injection)	• Install steam injection wells in filled ravine to heat subsurface and enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Install steam injection wells above wood waste layer at former coal tar dump area to heat subsurface and enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Install steam injection wells in the underlying Copper Falls Aquifer to heat subsurface and enhance the migration of NAPL. • Install additional groundwater extraction wells and SVE wells to recover fluids and vapors. • Modify existing treatment system, and treat recovered fluid on site.	• Monitored natural attenuation • Institutional controls • Soil vapor extraction • Groundwater extraction • Treat air stream from SVE prior to discharge. • Treatment of SVE condensate prior to discharge. • Dual Phase Recovery • Containment using surface and vertical barrier walls
Alternative GW9 Removal using Groundwater Extraction	• Continue to operate EW-4 as down gradient barrier well for shallow groundwater contamination in filled ravine. • Continue to operate existing treatment system.	• Install horizontal wells in saturated fill unit. • Construct building at Kreher Park for groundwater treatment equipment. • Treat contaminated groundwater on site	• Install extraction wells in the filled ravine to recover contaminated groundwater and NAPL. • Continue to operate EW-1, EW-2, and EW-3. • Modify existing treatment system, and treat recovered fluid on site.	• Monitored natural attenuation • Institutional controls • Containment using surface and vertical barrier walls • Ozone sparging • Surfactant Injection • Chemical oxidation • Electrical resistance heating • Dynamic underground stripping

3.4 Evaluation of Potential Remedial Alternatives for Groundwater

Potential remedial alternatives for groundwater were evaluated in this section in accordance with the threshold criteria, primary balancing criteria, and modifying criteria described in Section 1.2 above.

3.4.1 Threshold Criteria

Threshold criteria, which relate to statutory requirements that each alternative must satisfy to be eligible for selection, include:

- Overall protection of human health and the environment
- Compliance with Applicable or Relevant and Appropriate Requirements (ARARs).

The "no action" alternative will not satisfy threshold criteria; it will not result in the protection of human health and the environment. Containment technologies (surface and vertical barriers) will prevent exposure to contaminants and prevent the off site migration of contaminants with groundwater. The remaining potential remedial alternatives for groundwater will result in a reduction in mass, toxicity, and mobility of contaminants, which will result in the overall protection of human health and the environment.

The "no action" alternative will not achieve compliance with ARARs. However, the remaining potential remedial alternatives for groundwater will achieve compliance with ARARs as summarized in Table 2 in Attachment 1.

3.4.2 Balancing Criteria

The primary *balancing criteria*, which are the technical criteria upon which the detailed analysis is primarily based, include:

- Long-term effectiveness and permanence
- Reduction of toxicity, mobility, or volume through treatment
- Short-term effectiveness
- Implementability
- Cost.

3.4.2.1 Long Term Effectiveness and Permanence

Each remedial alternative is evaluated as to magnitude of long-term residual risks, adequacy of controls, and reliability of long-term management controls in restoring soil contamination. Table 3-2 presents an evaluation of the long-term effectiveness and permanence of each alternative.

Table 3-2. Evaluation of Long-term Effectiveness and Permanence for Potential Groundwater Remedial Alternatives

<table>
<tr><th>Alternative</th><th>Magnitude and Type of Residual Risk</th><th>Adequacy and Reliability of Controls</th></tr>
<tr><td><u>Alternative GW1</u>
No Action</td><td>• Potential risk to human health or the environment, if any, would not be reduced.</td><td>• There are no remedial actions or controls associated with this alternative.</td></tr>
<tr><td><u>Alternative GW2</u>
Containment Using Engineered Surface and Vertical Barriers</td><td>• Containment of shallow groundwater will reduce long-term potential risk to human health and the environment at the Site.
• The risk levels for the underlying Copper Falls aquifer will not be reduced.
• Natural attenuation monitoring for shallow groundwater may be needed to evaluate on-going risk to human health and the environment.</td><td>• Would be effective for shallow groundwater, but not the Copper Falls aquifer.
• Long-term operation, maintenance, and monitoring will be required to ensure containment is effective.
• Institutional controls could be implemented to prevent long-term exposure to residual subsurface contamination.</td></tr>
<tr><td><u>Alternative GW3</u>
In-situ Treatment using Ozone Sparging</td><td rowspan="7">• Removal of significant volume of NAPL will reduce long-term potential risk to human health and the environment at the Site.
• Site restoration will include surface barriers to prevent long-term exposure to shallow groundwater contamination.
• Natural attenuation monitoring for shallow groundwater and deep groundwater in the underlying Copper Falls aquifer may be needed to evaluate on-going risk to human health and the environment.</td><td rowspan="6">• Would be effective for Copper Falls aquifer, and could also be used for shallow groundwater contamination
• In-situ treatment could be completed in relatively short time frame, but long-term operation, maintenance, and monitoring will be required to ensure containment is effective.
• Institutional controls could be implemented to prevent long-term exposure to residual subsurface contamination.</td></tr>
<tr><td><u>Alternative GW4</u>
In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery</td></tr>
<tr><td><u>Alternative GW5</u>
In-situ Treatment using Permeable Reactive Barrier Walls</td></tr>
<tr><td><u>Alternative GW6</u>
In-situ Treatment using Chemical Oxidation</td></tr>
<tr><td><u>Alternative GW7</u>
In-situ Treatment using Electrical Resistance Heating</td></tr>
<tr><td><u>Alternative GW8</u>
In-situ Treatment using Dynamic Underground Stripping (Steam Injection)</td></tr>
<tr><td><u>Alternative GW9</u>
Removal using Groundwater Extraction</td><td>• Long-term operation, maintenance, and monitoring will be required to ensure containment is effective.
• Institutional controls could be implemented to prevent long-term exposure to residual subsurface contamination.</td></tr>
</table>

3.4.2.2 Reduction of Toxicity, Mobility or Volume through Treatment

The remedial alternatives are evaluated for permanence and completeness of the remedial action in significantly reducing the toxicity, mobility, or volume of hazardous materials through treatment. Each alternative is evaluated based on the treatment processes used, the volume or amount and degree to which it destroys or treats hazardous materials; the expected reduction in toxicity, mobility, or volume provided by the alternative; the extent to which the treatment is irreversible; and the types and quantities of residuals that will remain following treatment. Table 3-3 presents a summary of this evaluation.

Table 3-3. Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment for Potential Groundwater Remedial Alternatives

Alternative	Treatment Process Used and Materials Treated	Volume of Material Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative GW1 No Action	None	None	None	Not applicable	Not applicable
Alternative GW2 Containment Using Engineered Surface and Vertical Barriers	No treatment prior to containment of shallow groundwater encountered in shallow fill unit at Kreher Park. Not feasible for Copper Falls aquifer.	No treatment but the fill unit in Kreher Park, which is approximately 11.5 acres in size, and is an average of 12 feet thick, will be contained. No treatment for Copper Falls Aquifer.	No reduction in contaminant mass, but containment will prevent off site exposure for shallow groundwater. No reduction for Copper Falls Aquifer.	Contained fill at Kreher Park will remain on site. Will not influence implementation of any remedial alternative for Copper Falls.	All fill material, including the wood waste layer and contaminated soil in the former coal tar dump area would remain on site within the contained area. Does not address contamination in Copper Falls Aquifer.
Alternative GW3 In-situ Treatment using Ozone Sparging	Inject ozone to oxidize and destroy contaminants. Can also be used to displace NAPL that could be recovered by groundwater extraction.	Can be used to oxidize and destroy contaminants for shallow groundwater plume in upper bluff area and Kreher Park, and for underlying Copper Falls Aquifer.	Can reduce dissolved phase contamination concentrations by 50 to 75%. Can also enhance NAPL recovery.	Ozone sparge is a chemical oxidation reaction, and is irreversible.	Ozone sparge is a chemical oxidation process that destroys contaminant to CO_2 and H_2O end product by chemical oxidation.
Alternative GW4 In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery	Injection of a surfactant to enhance NAPL removal by vacuum enhanced recovery.	Surfactant injection is intended to enhance removal of NAPL.	Significant removal of NAPL can be expected, but multiple applications may be needed.	Removal of NAPL is irreversible. Surfactant is removed concurrent with NAPL; no lasting impacts from surfactant injection.	Not intended for dissolved phase contamination, but removal of NAPL will remove source for dissolved phase contamination.
Alternative GW5 In-situ Treatment using Permeable Reactive Barrier Walls	Install a PRB wall to treat dissolved phase contaminants in shallow aquifer by adsorption onto GAC material used to construct PRB as groundwater passes through it. Not feasible for Copper Falls aquifer.	Contaminants from contained area in Kreher Park are treated as they pass through the wall. No treatment for Copper Falls aquifer.	Significant reduction of dissolved phase contaminants passing through PRB wall from confined area in Kreher Park can be expected. No reduction for Copper Falls aquifer	Removal of contaminants from groundwater will be irreversible, but contained fill at Kreher Park will remain on site. Will not influence implementation of any remedial alternative for Copper Falls.	All fill material, including the wood waste layer and contaminated soil in the former coal tar dump area would remain on site within the contained area. Does not address contamination in Copper Falls aquifer.

Table 3-3. Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment for Potential Groundwater Remedial Alternatives

Alternative	Treatment Process Used and Materials Treated	Volume of Material Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative GW6 In-situ Treatment using Chemical Oxidation	Inject liquid reagent to oxidize and destroy contaminants. Can also be used to increase mobility and displace NAPL that could be recovered by groundwater extraction.	Can be used for shallow groundwater plume in upper bluff area and Kreher Park, and for underlying Copper Falls aquifer.	Significant reduction in dissolved phase contamination, and increase in the mobility of NAPL can be expected.	Chemical oxidation is an irreversible reaction, but it can result in a permanent change to the aqueous geochemistry of the aquifer.	Chemical oxidation destroys contaminant to CO_2 and H_2O end product by chemical oxidation.
Alternative GW7 In-situ Treatment using Electrical Resistance Heating (ERH)	Install electrodes in contaminated zone to heat aquifer to decrease viscosity and increase solubility and mobility of NAPL that is recovered by groundwater extraction or soil vapor extraction.	Can be used for shallow groundwater plume in upper bluff area and Kreher Park, and for underlying Copper Falls aquifer.	Significant removal of mobile and immobile NAPL and dissolved phase contaminants can be expected.	ERH is a thermal treatment process; no lasting impacts from thermal treatment.	Removal of NAPL will remove source for dissolved phase contamination.
Alternative GW8 In-situ Treatment using Dynamic Underground Stripping (DUS) / Steam Injection	Inject steam into contaminated zone to heat aquifer and increase solubility and mobility of NAPL that is recovered by groundwater or soil vapor extraction.	Can be used for shallow groundwater plume in upper bluff area and Kreher Park, and for underlying Copper Falls aquifer.	Significant removal of mobile and immobile NAPL and dissolved phase contaminants can be expected.	DUS / steam injection is a thermal treatment process; no lasting impacts from thermal treatment.	Removal of NAPL will remove source for dissolved phase contamination.
Alternative GW9 Removal using Groundwater Extraction	Utilizes groundwater as a carrier to remove NAPL and dissolved phase contaminants.	Can be used for shallow groundwater plume in upper bluff area and Kreher Park, and for underlying Copper Falls aquifer.	Significant removal of mobile NAPL and dissolved phase contaminants can be expected over an extended period of time.	Treatment of extracted groundwater will be irreversible.	Will removed mobile NAPL, but immobile NAPL may remove as source for dissolved phase contamination.

3.4.2.3 Short Term Effectiveness

The evaluation of short-term effectiveness is based on the degree of protectiveness of human health achieved during construction and implementation of the remedy. Potential implementation risks to the community and site workers and mitigation measures for addressing those risks are included in this evaluation. In addition, environmental impacts during implementation and the time required to achieve the RAOs must also be considered in the evaluation of this criterion. Table 3-4 summarizes the results of this evaluation.

Table 3-4. Evaluation of Short Term Effectiveness for Potential Groundwater Remedial Alternatives

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
Alternative GW1 No Action	None	No additional impact to the environment	RAOs will not be achieved.
Alternative GW2 Containment Using Engineered Surface and Vertical Barriers	Actions to protect community and site workers during remediation can be implemented.	All fill material will remain in Kreher Park along with fill material at upper bluff area, but containment will prevent contaminant migration from contained area. No impact to Copper Falls aquifer.	Containment construction can be completed in short time frame. Post remediation monitoring for residual contamination remaining on site may be needed to ensure compliance with RAOs. Long-term operation, maintenance, and monitoring will be needed for Kreher Park.
Alternative GW3 In-situ Treatment using Ozone Sparging		Will reduce dissolved phase contaminant concentrations and enhance NAPL removal in shallow and deep plumes.	In-situ treatment can be completed in short time frame. Post remediation monitoring for residual contamination remaining on site may be needed to ensure compliance with RAOs
Alternative GW4 In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery		Will enhance NAPL removal.	
Alternative GW5 In-situ Treatment using Permeable Reactive Barrier Walls		All fill material will remain in Kreher Park along with fill material at upper bluff area, but PRB will prevent contaminant migration from contained area. NAPL will impact performance of the PRB. No impact to Copper Falls aquifer	
Alternative GW6 In-situ Treatment using Chemical Oxidation		Will reduce dissolved phase contaminant concentrations and enhance NAPL removal in shallow and deep plumes.	
Alternative GW7 In-situ Treatment using Electrical Resistance Heating			
Alternative GW8 In-situ Treatment using Dynamic Underground Stripping (Steam Injection)			

Table 3-4. Evaluation of Short Term Effectiveness for Potential Groundwater Remedial Alternatives

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
Alternative GW9 Removal using Groundwater Extraction	Actions to protect community and site workers during remediation can be implemented.	Will remove dissolved phase and NAPL contaminants and prevent off site migration of contaminants with groundwater.	Long-term operation, maintenance, and monitoring of groundwater extraction system will be required Monitoring will be used to ensure compliance with RAOs

3.4.2.4 Implementability

Implementability is based on the evaluation of technical feasibility, administrative feasibility, and the availability of services and materials. Technical feasibility considers the following factors:

- difficulties that may be inherent during construction and operation of the remedy;
- the reliability of the remedial processes involved;
- the flexibility to take additional remedial actions, if needed;
- the ability to monitor the effectiveness of the remedy;
- the availability of offsite treatment, storage, and disposal facilities; and,
- the availability of needed equipment and specialists.

Administrative feasibility considers permitting and regulatory approval and coordination with other agencies. Table 3-5 presents a summary of this evaluation.

Table 3-5. Evaluation of Implementability for Potential Groundwater Remedial Alternatives

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
Alternative GW1 No Action	Additional remedial actions could be easily implemented. No other relevant technical issues.	Not applicable.	No permitting required, but will likely not be able to obtain regulatory approval.	None required.
Alternative GW2 Containment Using Engineered Surface and Vertical Barriers	Well suited for Kreher Park Miller Creek formation is shallow; not suited for confined Copper Falls aquifer. Wood waste layer may result in minor installation problems. Unlikely that additional remedial action for shallow groundwater will be required.	Containment is a reliable Containment technology will prevent exposure and contaminant migrations via shallow groundwater,	Regulatory agency and community approval likely. .	Conventional construction Specialized and conventional equipment and materials required are commercially available.
Alternative GW3 In-situ Treatment using Ozone Sparging	Installation of sparge wells may be difficult in shallow groundwater areas due to buried structures and wood waste layer. Groundwater extraction would be needed if used to enhance NAPL recovery.	Reliable technology for dissolved phase contamination. Can also be used to enhance NAPL recovery.	Minimal permitting requirements. Regulatory approval likely. .	Convention drilling and trenching equipment will be used. Would require specialized equipment that is commercially available.
Alternative GW4 In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery	Buried structures and wood waste may prevent installation of sparge points. Groundwater extraction would be needed if used to enhance NAPL recovery.	Reliable technology for enhanced NAPL recovery.	Will require permit for injection. Regulatory approval likely. .	Convention drilling equipment and vacuum truck will be used. Will use commercially available surfactant.
Alternative GW5 In-situ Treatment using Permeable Reactive Barrier Walls	Well suited for Kreher Park Miller Creek formation is shallow; not suited for confined Copper Falls aquifer. Wood waste layer may result in minor installation problems. Unlikely that additional remedial action for shallow groundwater will be required.	Reliable passive system, but will require long-term monitoring to evaluate effectiveness.	Regulatory agency and community approval will be required for construction. Regulatory approval likely. .	Conventional construction equipment would be used. Material used to construct the PRB wall is commercially available.
Alternative GW6 In-situ Treatment using Chemical Oxidation	Injection into areas with buried structures and wood waste may be difficult in shallow groundwater. Groundwater extraction would be needed if used to enhance NAPL recovery.	Reliable technology for dissolved phase contamination, and can be used to enhance NAPL recovery.	Will require permit for injection. Regulatory approval likely.	Conventional drilling equipment used for injection Would use commercially available surfactant.

Table 3-5. Evaluation of Implementability for Potential Groundwater Remedial Alternatives

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
Alternative GW7 In-situ Treatment using Electrical Resistance Heating	Installation of wells or electrodes may be difficult in shallow groundwater areas due to buried structures and wood waste layer. Groundwater extraction would be needed if used to enhance NAPL recovery.	Reliable technology to enhance NAPL recovery.	Minimal permitting requirements. Regulatory approval likely. .	Highly specialized equipment available through vendors specializing in application of remedial technology
Alternative GW8 In-situ Treatment using Dynamic Underground Stripping (Steam Injection)			Will require permit for injection. Regulatory approval likely.	
Alternative GW9 Removal using Groundwater Extraction	Installation of wells may be difficult in shallow groundwater areas due to buried structures and wood waste layer. Can be easily used in combination with containment and several in-situ treatment technologies.	Reliable technology, but must be operated for an extended period of time.	Minimal permitting requirements. Regulatory approval likely. .	Conventional drilling and trenching equipment will be used. Treatment equipment is commercially available.

3.4.2.5 Cost

Preliminary estimated costs for potential groundwater remedial alternatives include estimated costs for site preparation implementation, and site restoration. Detailed cost estimates will be presented in the Feasibility Study in accordance with USEPA guidance document, A Guide to Developing and Documenting Cost Estimates (EPA and USACE, 2000). Annual operation, maintenance, and monitoring (OM&M) costs are estimated for each alternative. Long-term monitoring costs for each alternative will be further evaluated in the Feasibility Study. Additionally it is assumed that all work is contracted and the estimates do not account for possible economies of scale (i.e., completing all activities at the site concurrently). These cost estimates are developed primarily for the purpose of comparing remedial alternatives and not for establishing project budgets. A summary of potential groundwater remedial alternatives for groundwater is included in Table 3-6.

Table 3-6. Evaluation of Cost For Potential Groundwater Remedial Alternatives

	Shallow Groundwater			Deep Groundwater	
Alternative	**Upper Bluff Area**	**Kreher Park**	**Annual OM & M**	**Copper Falls aquifer**	**Annual OM & M**
Alternative GW1 No Action	$0	$0	$0	$0	$0
Alternative GW2 Containment Using Engineered Surface and Vertical Barriers	$140,000	$7,055,000	$127,000	--	--
Alternative GW3 In-situ Treatment using Ozone Sparging	$146,000	$984,000	$28,600	$785,500	$98,000
Alternative GW4 In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery	--	--	--	$709,500	$138,000
Alternative GW5 In-situ Treatment using Permeable Reactive Barrier Walls	$140,000	$9,220,000	$25,000	--	--
Alternative GW6 In-situ Treatment using Chemical Oxidation	$1,904,000	$480,000	$25,000	$3,566,000	$96,000
Alternative GW7 In-situ Treatment using Electrical Resistance Heating	$2,023,000	$937,000	$250,000	$3,560,000	$350,000
Alternative GW8 In-situ Treatment using Dynamic Underground Stripping (Steam Injection)	$1,590,000	$1,241,000	$25,000	$3,560,000	$35,000
Alternative GW9 Removal using Groundwater Extraction	--	$573,000	$98,000	$641,000	$103,000

3.4.3 Modifying Criteria

The third group, the *modifying criteria*, includes:

- State/Support agency acceptance
- Community acceptance.

As previously discussed, these last two criteria are typically formally evaluated following the public comment period, although they can be factored into the identification of the preferred alternative to the extent practicable.

3.5 Comparative Analysis of Potential Remedial Alternatives for Groundwater

In this section, as required by CERCLA and NCP regulations, the alternatives will undergo a comparative evaluation wherein the advantages and disadvantages of the alternatives will be concurrently assessed with respect to each criterion. The criteria considered as part of this comparative evaluation are defined in Section 2.4. Table 3-7 presents a summary of the comparative analysis.

Table 3-7 – Comparison of Potential Groundwater Remedial Alternatives

Criteria	Alt. GW-1 No Action	Alt. GW2 Containment using Surface and Vertical Barriers	Alt. GW3 In-situ Treatment using Ozone Sparging	Alt. GW4 In-situ Treatment using Surfactant Injection	Alt. GW5 In-situ Treatment using Permeable Reactive Barrier Walls	Alt. GW6 In-situ Treatment using Chemical Oxidation	Alt. GW7 In-situ Treatment using Electrical Resistance Heating	Alt. GW8 In-situ Treatment using Dynamic Underground Stripping/Steam Injection	Alt. GW9 Removal using Groundwater Extraction Wells
Overall Protection of Human Health and the Environment	None	Moderate	Moderate	High	Moderate	High	High	High	Moderate
Compliance with ARARs and TBCs	None	High	High	High	High	High	High	High	High
Long-term Effectiveness and Permanence	None	Low	High	High	Low	High	High	High	Moderate
Reduction of Toxicity, Mobility and Volume through Treatment	None	Moderate	Low	Moderate	Moderate	High	High	High	Moderate
Short-term Effectiveness	None	Very High	High	High	High	High	High	High	High
Implementability	None	Very High	High	High	Very High	High	High	High	High
Cost	None	Very High	Low	Low	Very High	High	Very High	High	Low
Agency Acceptance	None	High	High	High	High	High	High	High	High
Community Acceptance	None	Moderate	High	High	High	High	High	High	High

3.5.1 Overall Protection of Human Health and the Environment

Alternative GW1 (no action) offers no additional human health and the environment because no additional actions would be taken to address groundwater contamination at the Site. ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) offer an overall moderate level of protection because contaminants will be left on site. These materials will be contained and inaccessible to humans or biota, thereby reducing risk, but offer no protection for the underlying Copper Falls aquifer. ***Alternative GW9*** (removal using groundwater extraction wells) can be used for shallow and deep groundwater, but offers a moderate level of protection of human health and the environment in the long-term because operation will require an extended period to achieve RAOs. The remaining alternatives offer high levels of protection because each technology will result in the removal of a significant contaminant mass, NAPL in particular, from the subsurface.

3.5.2 Compliance with ARARs and TBCs

Alternative GW1 (no action) will not achieve compliance with ARARs and TBCs. Compliance with ARARs and TBCs could be achieved for the remaining remedial alternatives for groundwater. Implementation will require that engineering and construction actions be developed and completed in compliance with federal and state regulations.

3.5.3 Long-term Effectiveness and Permanence

Long-term effectiveness and permanence considers long-term residual risks, adequacy of controls, and reliability of long-term management controls in restoring soil contamination. ***Alternative GW1*** (no action) will not provide any long-term benefit; no additional actions will be taken to address groundwater contamination at the Site. ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) offer low levels of effectiveness and permanence over the long term of protection. Although risk will be reduced by containment of contaminated material, contaminants will be left on site. Additionally, both are limited to shallow groundwater; neither is feasible alternative for the underlying Copper Falls aquifer. ***Alternative GW9*** (removal using groundwater extraction wells) will provide a moderate level of effectiveness and permanence over the long term; operation will be required for an extended period to achieve RAOs. The remaining alternatives have high levels of effectiveness and permanence over the long term because each technology will result in the removal of a significant contaminant mass, NAPL in particular, from the subsurface.

3.5.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Reduction of toxicity, mobility, or volume of hazardous materials through treatment considers the treatment processes used, the volume or amount and degree to which it destroys or treats hazardous materials; the expected reduction in toxicity, mobility, or volume provided by the alternative; the extent to which the treatment is irreversible; and the types and quantities of residuals that will remain following treatment. ***Alternative GW1*** (no action) will not result in a reduction in the toxicity, mobility, or volume of contaminated soil. ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) will not result in the toxicity or volume of contaminant mass. However, both will reduce contaminant mobility for shallow groundwater, but not for the Copper Falls. ***Alternative GW9*** (removal using groundwater extraction wells) will result in a reduction in the toxicity, mobility, and volume of contaminant mass, but operation will be required for an extended period to achieve RAOs. Implementation of the remaining in-situ treatment alternatives will result in the highest degree of reduction of toxicity, mobility, and volume of impacted groundwater. However, amount of volume reduction will vary for each of the remaining in-situ treatment.

3.5.5 Short-term Effectiveness

Short-term effectiveness considers potential implementation risks to the community and site workers, environmental impacts, and time required to achieve RAOs. Implementation of ***Alternative GW1*** (no action) will not achieve RAOs or improve environmental impacts in the short-term, but it will allow maximum protection to the community and workers during remediation. The short-term effectiveness for the remaining alternatives is considered high. Each alternative can achieve RAOs and will reduce environmental impacts in the short-term by removing contaminant mass or preventing the off site migration of contaminants. Containment, in-situ, and removal technologies evaluated in this report will require minimal effort to protect the community and workers during remediation.

3.5.6 Implementability

Implementability considers technical feasibility, administrative feasibility, and the availability of services and materials. ***Alternative GW1*** (no action) will require the least amount of effort for implementability. Additionally, because no remedial action will occur, there would be no difficulty in implementing additional remedial actions at a later date. ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) have a very high degree of implementability. The remaining alternatives have a high degree of implementability. However, buried structures in the upper bluff area and the wood waste layer in Kreher Park may limit the effectiveness of in-situ treatment for shallow and deep groundwater in these areas. Removal of the buried structures concurrent with remedial alternatives evaluated for soil in Section 2.0 may ease implementation of the in-situ treatment and removal alternatives for the Copper Falls. If removal and disposal (on- or off site) or on site treatment is selected as a remedial response for soil, or if containment is selected for shallow groundwater, in-situ treatment and or removal will not be necessary for soil and shallow groundwater contamination, but one or more of the in-situ or removal technologies evaluated in this report will be required for the Copper Falls aquifer.

3.5.7 Cost

Preliminary cost estimates for potential remedial alternatives for groundwater include site preparation, implementation of the remedial response, and site restoration. There are no costs associated with ***Alternative GW1*** (no action) because none of these activities will be completed. For shallow groundwater, ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) have high installation. Annual OM&M cost for ***GW2*** are high due to long term groundwater recovery and disposal costs, but low for ***GW5***, which relies on - situ treatment. Cost for implementation of the in-situ treatment ***Alternatives GW6*** (chemical oxidation), ***GW7*** (ERH), and ***GW8*** (steam injection) area also high with low annual OM&M costs[16]. ***Alternatives GW3*** (ozone sparging) has low implementation and annual OM&M costs. Implementation costs for ***Alternatives GW9*** are the lowest, but have high annual OM&M cost for continued operation, which may be required for an extended period of time.

For the Copper Falls Aquifer, in-situ treatment ***Alternatives GW6*** (chemical oxidation), ***GW7*** (ERH), and ***GW8*** (steam injection) implementation costs area high. ***GW6*** has high OM&M cost, and ***GW7*** and ***GW8*** have low OM&M annual costs. In-situ treatment ***Alternatives GW3*** (ozone sparging), and ***GW4*** (surfactant injection) implementation costs area low, but have high annual OM&M costs. As with shallow groundwater, implementation costs for ***Alternatives GW9*** are the lowest, but have high annual OM&M cost for continued operation, which may be required for an extended period of time.

3.5.8 Agency and Community Acceptance

With the exception of no action, all remedial alternatives for groundwater evaluated in this report should be acceptable to the regulatory agency and community. ***Alternatives GW2*** and ***GW5*** (containment using surface and vertical barriers and in-situ treatment using PRB walls) will likely be the least desirable to the community because contaminant may limit future Site use; building will likely be restricted at Kreher Park to prevent disturbance of the contained area. ***Alternative GW9*** (removal using groundwater extraction wells) can be used to achieve RAOs, it may be the least desirable to the Agency because it will take the longest to complete.

[16] These in-situ remedial alternatives are limited to the coal tar dump area. Significantly higher costs would be expected if implemented for all of Kreher Park.

4.0 Sediment

As described in the RI and the Alternatives Tech Memo, NAPL is present in sediments in the offshore zone along the Kreher Park shoreline. The greatest mass of NAPL-impacted material extends between the marina and an area north of the former WWTP from 100 to 300 feet from the shore.

A wood waste layer varying from sawdust-sized particles to timber overlies much of the impacted sediment at depths from a few inches to more than ten feet. Approximately 95 percent of the impacted sediments are covered by this wood waste layer. The greatest wood waste thickness is found at the area east of the WWTP, where the former Schroeder Lumber sawmill operated. An estimated 25,000 cubic yards of this material is present in this layer. The greatest contaminant mass is found immediately below the wood waste layer at the sediment surface.

Based upon estimates developed in the Alternatives Tech Memo, the areal extent of contaminated sediment was first calculated for total PAH concentrations exceeding 10 ppm dry weight (dwt)[17]. Approximately 16 acres of the Site contains total PAH concentrations in excess of 10 ppm. The volume of sediment in the 16 acres was then calculated for contamination up to maximum depths of 4 and 10 feet. Total PAHs exceeding 10 ppm include an estimated 77,822 cubic yards of sediment between 0 and 4 feet, and an estimated total of 133,906 cubic yards of sediment up to a maximum depth of 10 feet. All volume estimates include wood waste overlying, and mixed with, the contaminated sediment.

The Alternatives Screening Tech Memo identified the following remedial alternatives as retained for further evaluation:

Alternative SED-1: No Action
Alternative SED-2: Containment with a CDF
Alternative SED-3: Containment with subaqueous capping
Alternative SED-4: Removal

Each of these alternatives includes potentially multiple ex-situ treatment and disposal processes which will be further discussed in this section.

This section, presenting a Comparative Analysis of Sediment Alternatives, is organized as follows:

Section 4.1: Remedial Action Objectives for Sediment
Section 4.2: Potential Remedial Alternatives for Sediment

[17] For purposes of estimating sediment volumes the 9.5 ug PAH/g dwt was rounded to 10 ppm and it was assumed that the concentration was on a dry weight basis.

Section 4.3: Development of Remedial Alternatives for Sediment
Section 4.4: Detailed Analyses of Remedial Alternatives
Section 4.5 Comparative Analyses of Remedial Alternatives

4.1 Remediation Action Objectives for Sediment

As described in the RAO Technical Memorandum (Appendix A to the Remedial Investigation; URS 2007), in general, the goals of remedial action for sediment are to prevent human ingestion or direct contact with sediments having contaminants of potential concern (COPCs) which pose an unacceptable health risk. Similarly, for ecological receptors, the general goal is to prevent direct contact with or ingestion of sediments or of prey having levels of COPCs that would pose an unacceptable risk to populations of ecological receptors or individuals of protected species. Remedial action objectives for sediment[18] include:

- Protect human health by eliminating exposure (direct contact, ingestion, inhalation, fish ingestion) to sediment with COPCs in excess of regulatory or risk-based standards;
- Conduct free product removal whenever it is necessary to halt or contain the discharge of a hazardous substance or to minimize the harmful effects of the discharge to the air, land or water; and,
- Protect populations of ecological receptors or individuals of protected species by eliminating exposure (direct contact with incidental ingestion of sediments or of prey) to sediment with levels of COPCs that would pose an unacceptable risk.

With the exception of iron, the cumulative risks estimated for the human health recreational receptor exposures to sediments were below EPA's target risk levels.

For ecological receptors, USEPA set the sediment PRG at 2295 μg PAHs/g Organic Carbon (OC) or 9.5 ug PAH/g dwt at 0.415% OC based upon their "best professional judgment". In addition, USEPA directed that, "if the final depth of sediments will be less than 6 feet, the PRG for any active remedial intervention will be adjusted downward as based upon ultraviolet light (UV) extinction coefficients measured in Site waters. In addition, sediments in greater than 6 feet of water having a concentration equal or less than 2,295 ug PAH/g OC (9.5 ug PAH/g dwt at 0.415% OC) and sediments in 6 feet or less of water having a concentration greater than a UV-adjusted PRG will be monitored to assure that there are no unacceptable impacts to benthic community and that the levels of PAHs in surface sediments decrease over time to 1340 ug PAH/g OC (5.6 ug PAH/g dwt at 0.415% OC)."

4.2 Potential Remedial Alternatives for Sediment

Remedial technologies retained for screening were used to develop potential remedial alternatives for sediment. Remedial alternatives for groundwater presented in this report are summarized in Table 4-1.

[18] These RAOs were provided by USEPA in comments to the RAO Technical Memorandum.

Table4-1 Screening and Assembly of Remedial Technologies for Sediment

GRA	Technology	Process Option	Screening and Alternative Assembly Effectiveness	Screening Decision
No Action	None	N/A	Required	Retained as Alternative SED-1.
Institutional Controls	Physical, Engineering or Legislative Restrictions	Access Restrictions	Potential protection for limited areas; used in combination with other alternatives	Retained as a potential component of other alternatives.
Monitored Natural Recovery	Physical degradation	Desorption, diffusion, dilution, volatilization	Slow processes but for limited areas may be effective in combination with other natural recovery mechanisms	Retained only as a potential component of other alternatives.
	Biological/ chemical degradation	Dechlorination (aerobic and anaerobic)		
	Physical processes	Burial	Evidence of net deposition is limited; however contribution of clean sediment to areas of the Site and subsequent bioturbation would lead to reduced PAH levels in surface sediments. Also, placement of engineering structures could lead to increased deposition	
		Resuspension and transport	Slow process but for limited areas may be effective in combination with other natural recovery mechanisms	
Containmen t	Subaqueous capping	Sand cap Composite cap Armored cap	A cap utilizing aspects of these three types of caps could be effective in combination with removal of approximately the top four feet of sediment in the nearshore.	Retained as a component of Alternative SED-3.
Containment (cont.)	Confined disposal facility	Sheet pile enclosure with impervious cap and groundwater management	Effective in reducing mobility of all Site contaminants and eliminates potential exposure pathways to humans and ecological receptors. May have administrative implementability issues. Would require substantial mitigation.	Retained as Alternative SED-2. Process options may be used singly or in combination.
		Combination of sheet pile and slurry wall enclosure with impervious cap and groundwater management		

GRA	Technology	Process Option	Screening and Alternative Assembly	
			Effectiveness	Screening Decision
Removal	Dredging	Mechanical	Dredging is standard practice and generally effective; however site conditions may limit effectiveness. Mechanical dredging is expected to be more effective for debris removal or for dredging in areas where there is debris; however it will also result in the maximum loss of VOCs and SVOCs to the atmosphere through volatilization.	Retained as a component of Alternatives SED-2, SED-3, and SED-4.
		Hydraulic	Dredging is standard practice and generally effective; however site conditions may limit effectiveness. Hydraulic dredging will be ineffective in areas where there is a substantial amount of debris; however it is more effective for limiting volatilization and dispersal of NAPL.	
		Excavator	Excavation of sediment is standard practice and generally effective; however site conditions may limit effectiveness. Excavation is expected to have the same potential limitations that mechanical dredging would have.	
	Excavation in the dry	Excavator	Can be effective but at very high cost for entire Site. May have applications at this Site for supplementing other removal technologies in the nearshore areas, perhaps for debris removal.	
Ex-situ Treatment	Physical	Screening	Effective for wood debris as part of other alternative.	Retained as a component of Alternatives SED-2, SED-3, and SED-4.
		Crushing		
		Floatation		
		Hydraulic Separation		
	Thermal	High and Low Temperature Thermal Desorption	Effective at destroying organics. Effectiveness limited by supporting technologies and wood debris content	Retained as a component of Alternatives SED-3, and SED-4.
		Incineration	Effective at destroying organics. Effectiveness limited by supporting technologies	
Disposal	On site disposal	Nearshore CDF	Effective in reducing mobility and toxicity of all Site contaminants and eliminating potential exposure pathways to humans and ecological receptors.	Retained as Alternative SED-2.
		Beneficial use or fill	Effective provided residuals are "clean"	Retained as a component of Alternatives SED-3 and SED-4.

GRA	Technology	Process Option	Screening and Alternative Assembly Effectiveness	Screening Decision
	Off site disposal	NR 500WAC Landfill	Effective and administratively implementable	Retained as potential components of Alternatives SED-3 and SED-4.
		Upland confined fill	Effective provided it can be permitted	
		Upland beneficial use or fill	Effective provided residuals are "clean"	

As shown in the above table, more than one process option may be available for a given technology. Examples include thermal treatment, on site disposal, and off site disposal. In these cases, there is not a sufficiently significant difference in the technologies to warrant selection of one process option over another at this time. However, a distinction would be made during the Remedial Design phase based on availability and costs. Therefore, both processes may be included in subsequent discussions.

4.2.1 No Action

There are no process options associated with a "no action" alternative; however, no action was retained as required by the NCP as a basis for comparing the other alternatives. No action requires no planning, maintenance, or monitoring. It is not the same as "institutional controls" or "monitored natural recovery," each of which require some maintenance and monitoring. A "no action" alternative, however, does not meet the RAOs for the Site.

4.2.2 Containment

There were two containment processes retained: subaqueous capping, which is a component of Alternative SED-3, and a CDF, which is the primary component of Alternative SED-2.

4.2.2.1 Subaqueous Capping

One subaqueous capping option has been retained for further evaluation. This is a nearshore cap that would be placed after dredging sediment to a depth such that placement of the cap will not interfere navigation. For this evaluation it has been assumed, the top four feet of sediment in areas exceeding the proposed sediment cleanup level of 2,295 ug PAH/g OC (9.5 ug PAH/g dwt at 0.415% OC) will be removed to provide sufficient depth for emplacement of an armored cap and not decrease the lake bottom depth in the area. Cap material considered in this application would be natural sand, organo-clays and/or carbon or other amendments to adsorb contaminants and rock armoring to resist erosion. Geomembranes will also be considered in the design of a cap.

4.2.2.2 CDF Process

This remedial alternative consists of a CDF that would cover sediments that are impacted by substantial levels of wood debris as well as by substantially elevated levels of SVOCs and VOCs, including NAPL. In addition, the CDF would cover areas on upland portions of the Site that are impacted by wood material mixed with coal tar wastes. Sediments outside this CDF footprint that exceed the sediment cleanup level of 2,295 ug PAH/g OC (9.5 ug PAH/g dwt at 0.415% OC) would be dredged or excavated and placed in the CDF where they would be permanently stored. This alternative would also include a cap and drainage system to eliminate or minimize infiltration from precipitation and eliminate groundwater infiltration. It can be designed as a comprehensive alternative that would address contaminated sediments, soils and groundwater. Since this alternative would involve filling of the nearshore area to levels above the lake level, it will require compensatory mitigation for wetland loss.

The proposed CDF would consist of the following components:

Sheet Pile Enclosure

A 3,700-foot-long sheet pile wall would be constructed enclosing roughly 17 acres (approximately six acres in the lake and 11 acres in Kreher Park). The sheet piling on land would be driven into unimpacted silty clays below the water table to serve as a cut-off wall impeding the flow of groundwater through the contaminated sediments that are enclosed. The sheet piling in the lake would also be driven through the water and impacted sediment/debris layer into unimpacted silty clays of the Miller Creek formation. The sheet piling in the lake would be structurally supported and protected from wave and ice action by an armored dike. The extent of this armored dike will be determined in Remedial Design. The sheet piling would be sealed to achieve an average permeability of $1x10^{-7}$ cm/sec, using one of several commercially available sealing methods and products. The sealing process involves directly filling the voids in the joints using a polymer or bentonite material. This material is most often applied prior to driving the pile and the pile can be installed through water. Other processes available involve driving the pile and adding the sealant afterwards, either into the joint or into an enclosure formed by a two-inch angle iron welded to the outside of the sheet pile at the joint. Additional means of eliminating flux of contaminants for the CDF will be considered if treatability studies indicate they may be necessary.

Dredging

A mechanical dredge will be used that will either load directly to a barge or place sediment in a hopper with a screen/basket and grizzly[19] connected to a high-solids slurry pump. When the method of loading directly into a barge is used, the sediment would then be unloaded into the CDF with a crane. If a high-solids slurry pump method is used, a pipeline is used to hydraulically transfer sediments to the CDF and discharge them under the water into the CDF. A discharge

[19] Most treatment trains include coarse separation using grizzly screens as an initial treatment step. Grizzlies are the simplest and coarsest devices for removing small debris. Grizzly screens are made up of inclined parallel iron or steel bars spaced between one and 12 inches apart. The material to be screened is loaded either directly by bucket or front-end loader, or may be fed by conveyer. Objects larger than the spacing of the bars are separated into a separate stream that may be treated or disposed of independently. Grizzly screens are very rugged and require little maintenance.

nozzle such as a tremie may be used to control the discharge velocity and minimize suspended solids entrainment within the CDF. Other dredging procedures and controls would be as described in Section 4.2.3.

Water Treatment

Treatment would be provided to treat the water from dredging during filling of the CDF. Water treatment could include polymer addition to improve settlement of suspended solids followed by sand filtration and carbon adsorption to allow discharge to the City POTW or to the lake at levels that conform to water quality guidelines.

Capping and Geomembrane Cover

After disposal of dredged sediments in the CDF, a cap that would meet the requirements of a RCRA Class C or D landfill will be installed to cover impacted sediments and minimize infiltration from precipitation. This cover will be installed over the entire 17-acre area after the existing city wastewater treatment plant is demolished and removed. Contaminated sediments in the CDF will require time for consolidation and possible dewatering prior to installation of this layer. A two-foot thick sand cap will be placed over the CDF with a final topsoil layer for a vegetative or evapotranspiration cap. Limited use of stabilization of some sediments also may be a consideration such that the stabilized material would act as a pseudo-liner. A hydraulic control plan in the upland area may use alternative cap materials to minimize infiltration such as asphalt for a parking lot or clay layer.

Groundwater Control

Up gradient groundwater will be diverted around the CDF through use of drainage tiles and/or the use existing hydraulic control system for the filled ravine (EW-4 or other extraction wells). This includes discharges to storm drainage systems that would be a part of the hydraulic control plan for the upland and sediment capping area. This may also include vegetation plantings and landscaping to enhance evapotranspiration and drainage from the bluff.

4.2.3 Removal

While removal of contaminated sediment with dredges or excavators has been successfully implemented at a number of contaminated sediment sites, Site characteristics at Ashland provide several unique challenges. These challenges arise from the presence of large quantities of wood debris, including logs to depths of eight or more feet, and the presence of both dissolved phase VOCs and SVOCs and NAPL in sediments. These factors taken together result in a substantial potential for release of volatile contaminants to the air as well as for potential release of dissolved and NAPL to surface water. While this potential can often be addressed through use of hydraulic dredges which minimize the probability of escape and dispersion of these LNAPL and volatiles, the presence of large quantities of wood debris may preclude the effective use of hydraulic dredges in substantial portions of the Site. For this reason it is likely that debris removal primarily would need to be accomplished by mechanical dredges or excavators. With use of mechanical dredges or excavators, volatilization is expected to be significantly greater than what would occur if only hydraulic dredging was utilized.

If volatiles are released to the air, they may disperse beyond the immediate vicinity of dredging operations and onshore treatment operations, depending upon ambient weather conditions. With the proximity of a relatively large population in Ashland, this presents the real possibility of unacceptable exposure unless it is possible to design engineering controls. A preliminary evaluation based upon conservative assumptions of volatilization indicates that naphthalene and benzene released during dredging and sediment treatment activities would potential impact residential areas at levels exceeding air quality standards. Details regarding this assessment can be found in Attachment 2.

The removal alternative would therefore likely feature multiple removal technologies, such as use of mechanical dredging and/or excavation to remove debris, and hydraulic dredging once a sufficient amount of debris is removed.[20] To minimize volatilization of VOCs and SVOCs and limit dispersion of NAPL, the dredging operation would likely employ modular pontoon barges or scows that are configured in such a manner that turbidity “skirts” can be placed around them. Debris removal and dredging will take place in the “hole” made by the arrangement of pontoons or strategic placement of scows with open/out bottom ‘doors.’ Various types of equipment, including lattice-boom modified clamshell cranes, hydraulic cutterhead suction or extended articulating-boom excavators with modified thumb-bucket(s), would operate from these floating platforms depending upon their effectiveness. In areas where the presence of debris does not interfere with hydraulic dredging, hydraulic pumps installed directly on the excavators could be used. The scows or pontoon barges would be moved around using either a small tug or cables/swing-gear connected to the shore or off site anchor points. Anchor spuds could also be used.

Debris close to shore might also be removed by extended-boom excavators operating directly from shore or submerged/flooded-grounded (removable) piers made from modularized pontoons/barges.

Once dredged or excavated, debris and the sediment/debris mixture would be passed through grizzlies to separate out large wood into hoppers or scows with sediment locks. Water could be added to the sediment and moved hydraulically to tertiary treatment, settlement, dewatering and specialized treatment areas, possibly using a closed-circuit (return water) pipeline system. The wood debris would be handled separately.

Engineering controls for minimizing release of dissolved or free-phase contaminants to water beyond the Site would likely consist of redundant turbidity barriers and booms. Temporary sheet

[20] Various hydraulic equipment, such as cutterhead suction dredges, can deal with a certain amount of wood debris provided it can be cut/resized and pumped. A cutterhead suction dredge can crush the wood debris into smaller pieces and hydraulically move it with the sediment to separation and treatment facilities but would increase the amount of contaminated material(s) to be treated.

piling will also be considered if redundant turbidity barriers and booms are not effective. In addition, dredging operations can be suspended during conditions that render redundant turbidity barriers and booms ineffective.

Controls for minimization of volatile releases would have to be investigated further since covering over working dredges and adjacent water is difficult and would add complexity to maintaining more efficient dredge production rates. It is likely that remedial construction workers would have to use Class C personal protective equipment (PPE).

Because of the limitations on dredging in the winter, it is anticipated that 12 hour shifts, working 24 hours per day, seven days per week, would be used with an anticipated 'pay' production rate of 500-1,000 'in-place' cy per 24 hours, including debris handling. If this is achieved, then the dredging under any alternative should be able to be completed in one construction season (May through October).

Since dredging is a component of all remedial alternatives for sediment, a pilot-scale project is recommended to evaluate and optimize effectiveness and determine whether engineering controls can be used to minimize volatilization and dispersal of NAPL. A pilot could be conducted separately or on the "front end" of the dredging project. Because of time limitations, not all removal alternatives can be completed in one construction season if a pilot is conducted on the front end of the project. In removal alternatives that require dredging of more than about 60,00 cy, the pilot would have to be conducted separately the year prior to dredging.

Sediment removal is a component of Alternatives SED-2, SED-3 and SED-4, although different dredging processes may be used for certain elements of sediment removal. This will be described in more detail in Section 4.3.

4.2.4 Dewatering, Treatment, and Disposal Process Options

4.2.4.1 Dewatering Process Options

Sediment removed from the lake would be transported to settling ponds specifically constructed for dewatering purposes within the confines of Kreher Park. These ponds would be used for separating the liquid from the sediment, and decanting the water for treatment, effectively separating the sediment from the water. Sediment would be removed from the settling ponds and mechanically dewatered prior to being treated on site or shipped off site for disposal. The ponds would be constructed of clean locally-derived soil compacted in place.

Settling ponds are usually divided into three basins: primary, secondary, and return basins. The primary and secondary basins are used to allow solids to settle out of the sediment slurry. By the time the water reaches the return basin, most of the sediment that was suspended in the water has settled out. Following additional treatment to meet all regulatory standards, the water is then allowed to flow back into the lake. The sediment would take between 1 and 5 days to completely settle out.

Through use of flocculants or other additives, it would be possible to increase the settling rate of suspended sediment, thereby decreasing the time required to clarify the water prior to discharge. This would also lengthen the service life of any system, such as granular activated carbon, used to remove VOC and PAH from the water.

Prior to treatment or disposal at a landfill, sediment must be dewatered. USEPA has suggested three methods of dewatering (USEPA 1994):

1. "Passive" dewatering, where sediment is allowed to dry under ambient conditions. This could include settling basins where solids are allowed to settle by gravity, possibly aided by use of flocculants. VOCs or PAHs in the sediment could potentially be released to air, causing unacceptable risk, unless the sediment were dried in an enclosure with appropriate vapor controls.

2. "Mechanical" dewatering, where the sediment is processed through equipment that removes water by squeezing, centrifugation, filtering, or other similar means. Use of these methods will remove water rapidly, potentially reducing the exposure of the surrounding areas to vapors, given proper handling techniques. Water that is removed using these types of processes will contain VOCs, SVOCs, and NAPL and therefore will require treatment prior to discharge. .

3. "Active" dewatering; where sediment is heated to vaporize water. Using this method, it is anticipated that the level of vapors released will be higher than other methods; however, steps could be taken to minimize the exposure of the surrounding areas to these vapors.

Dewatering would be required for the alternatives that include treatment or off site disposal. Dewatering would not be required for the no-action alternative or and only passive dewatering would be required within a CDF.

Passive Dewatering

Settling ponds could be used for separating sediment from the water, and decanting the water for treatment. The ponds would be constructed of clean locally-derived low permeability soil compacted in place with a liner. Following settlement, sediment would be removed from the settling ponds and mechanically dewatered. Prior to transport to an off site location, sediment may require stabilization through addition of fly ash or cement dust to reduce the water content to acceptable levels.

Settling ponds are usually comprised of three basins: primary, secondary, and return basins. The primary and secondary basins are used to allow solids to settle out of the sediment slurry. By the time the water reaches the return basin, most of the sediment that was suspended in the water has settled out. Clarified water would be discharged to the sanitary sewer system, or treated through an oil/water separator, sand and carbon filters, following which and verifying that it meets water quality standards, the water would be allowed to flow back into the lake. The sediment would take between 1 and 5 days to completely settle out of the water.

Through use of flocculants or other additives, it would be possible to increase the settling rate of suspended sediment, thereby decreasing the time required to clarify the water prior to discharge. This would also lengthen the service life of any system, such as granular activated carbon, used to remove VOC and SVOCs from the water.

The CDF alternative would utilize the containment area as a passive settling basin during sediment placement in the CDF. Clear water would be pumped from the opposite side of the CDF as it is filled with sediment to maintain an approximately constant water level. This water would be run through an oil/water separator, settling chamber and filter (sand, bag, or cartridge) to remove fine particulate. The water would then be treated in a bed of activated carbon granules (GAC) to remove dissolved COPCs. If the sediment is pumped into the CDF, a treme' to discharge sediment to reduce the resuspension of sediment in the overlying water. This will reduce particulate and dissolved concentrations of COPCs and lower emissions and treatment requirements. The discharge from the CDF would be returned to Lake Superior or to the City of Ashland sanitary sewer system. Hydraulic dredging would generate the highest flow with approximately six to ten percent solids slurry and would be pumped to the CDF. Mechanical dredging would consider dewatering in the barge and then placed mechanically into the CDF or pumped from a dredge equipped with a high solids slurry pump and screen for debris removal. The intake water would be pumped from the CDF to the slurry pump on the dredge and be re-circulated to the CDF with the sediment. This method of hydraulic placement would reduce the water volume for treatment and minimize air emissions compared to hydraulic dredging.

For alternatives where the dredge material will be treated and disposed off site a settling pond will be located in Kreher Park. The dewatering pond would be about 4 acres and allow for settling and staging of the sediments for additional treatment options. The sediment would require filtering such as the plate and frame filter press system to meet the off site landfill requirements to remove free liquids or for the thermal treatment contingency alternative to reduce moisture for processing. A solids content of 45-75% solids would be needed for thermal treatment. The clear water overflow from the pond and re-circulated water from mechanical dewatering would be treated using settling and filtering before treatment with GAC and then discharged similar to the system described in the CDF alternative.

The solids from mechanical dredging may be dewatered in a barge and then placed in the ponds for additional dewatering and staging for mechanical dewatering. Solids content under a mechanical dredging scenario would likely be similar to in-situ levels of 25 to 60 % depending on the sand and wood debris content. All of the water treatment equipment would be the same but would be a much smaller flow and system than with using a hydraulic dredge.

Additional dewatering treatment on land could include a hydrocyclone to first separate the sand fraction of the sediment. If there is sufficiently large enough sand content and it can be demonstrated that the sand would meet concentrations of COPCs for reuse, this would reduce the amount of sediment for final dewatering and subsequent treatment and disposal.

4.2.4.2 Treatment Process Options

In the event the dewatered sediment can not be disposed after dewatering and/or stabilizing, on site treatment using mobile Low Temperature Thermal Desorption (LTTD) or High Temperature Thermal Desorption (HTTD) may be used to thermally extract the organic COPCs from the sediments and then incinerate the fumes in a secondary combustion chamber to achieve 99.99% destruction removal efficiency (DRE). The equipment would be located next to the dewatering facilities and would have a mechanical feed from the dewatered sediments stockpile. The lower the moisture potentially the greater throughput of the system. The first stage would be an indirectly heated rotating kiln to evaporate the water and volatilize the COPCs. This would discharge treated sediment to a hopper and the fumes and water vapor would be diverted into a secondary combustion chamber for incineration. The temperature would be raised in the chamber to a level needed to achieve the DRE.

An on site mobile incinerator would operate in a similar fashion as HTTD except the kiln would be direct-fired[21] and would cause some COPCs to be destroyed before the vapors reach the secondary combustion chamber. In addition the gas flow rates are higher since the fuel and air combustion gases are included in the gases sent from the kiln to the secondary combustion chamber.

For all thermal processes, an ash stockpile area would be needed and the ash would be trucked off site for fill or land disposal.

For land disposal alternatives without thermal treatment, stabilization treatment likely will be required to meet landfill requirements. The process would include a material holding tank and mixing tank to add sufficient cement and/or fly ash to meet the “no free liquids” standard. After mixing the sediment would be stockpiled for loading onto trucks for off site land filling. It is estimated that stabilization would increase sediment weight by about 10-percent[22]..

4.2.4.3 Disposal Process Options

Disposal is relocation and placement of removed materials into a site, structure or facility. Impacted and/or treated/stabilized sediment removed from the site may be disposed of at a number of off site commercial/industrial disposal facilities that meet the requirements of chapter

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[21] Medium and high temperature thermal desorption may also be direct-fired, but at a lower temperature than incineration.

22 This is on a weight basis and 10% is typical unless there is difficulty in the dewatering process. Testing will be needed to determine the stabilization formula required and will affect the increase in sediment weight. Disposal costs are normally on a weight basis.

NR 500 WAC and the EPA's "off site rule" (40 CFR 300.440). Out-of-state disposal facilities are also available. Off site disposal is being considered for both contaminated and treated/stabilized sediments.

A landfill is an engineered facility that provides long-term isolation and disposal of wastes. These facilities are designed to prevent the release of contaminants to groundwater, control runoff to surface water and limit dispersion of contaminants into the air. Through statute and case law, it has been determined that dredged sediment is classified as solid waste in Wisconsin (Lynch 1997, 1998). Wisconsin Statute Chapter 289 and NR 500 through NR 520 WAC address handling of solid waste and therefore handling of dredged sediment. Any in-state landfill approved for disposal of contaminated sediment must meet Wisconsin requirements for design, operation and maintenance of a Subtitle D landfill. WDNR has authority to issue exemptions from regulation under Wis. Stats chapter 289. Exemptions which cover dredged material exist in NR 500.08 WAC (beneficial reuse) and in Wis. Stats chapter 289.43 (8) and related sections of NR 500 WAC known as "Low Hazard Exemption". These exemptions may be applicable for treated or untreated sediment containing low or non-detectable levels of contaminants. Prior to disposal, all sediment will be required to be dewatered to an acceptable moisture content and meet applicable landfill acceptance criteria, including those regarding structural characteristics. As such, at a minimum, sediment will likely be mixed with appropriate materials to improve the strength of the sediment (e.g. kiln dust, fly ash etc.).

Landfill volume acceptance limitations for contaminated materials used for daily cover or for disposal, contained in NR 500 and NR 700 WAC, may require that disposal be approved by the WDNR or that multiple disposal facilities be utilized. Use of out-of-state landfills will be considered if volume acceptance limits within Wisconsin dictate. Out-of-state facilities will need to meet the individual state's requirements as well as 40 CFR 300.440.

Following the dewatering process, sediment would be transported to one or more disposal facilities by truck, rail, or barge. Five existing landfills have been identified within a 125 mile radius of the site. One of these facilities is a municipal landfill and may only accept treated sediment for daily cover. The remainder of the facilities are commercial landfills. An additional Wisconsin landfill was identified that can be accessed by rail service and is approximately 250 miles from the site. Estimated capacity for these landfills was obtained from WDNR and is current as of 2005. The combined remaining capacity according to the WDNR data is 17,500,000 cubic yards. A sixth landfill within 125 miles of the site is located in Michigan and according to the Michigan Department of Environmental Quality, its remaining capacity in 1999 was 2,700,000 cubic yards. Additional landfills capacity may be available in adjacent states (Minnesota, Illinois).

Alternatively, NSPW may initiate siting of a ch. NR 500 landfill in the Ashland area for solid materials removed from the Lakefront Site. This disposal option is dependent on the material volume (unlimited removal indicates in place volumes of 32,500 cy from the upper bluff, 223,000 cy from Kreher Park, and nearly 134,000 cy of sediment). The detailed analysis of this option will be included in the FS.

Wood Waste

There is the potential for generating a substantial quantity of wood waste if sediments are removed. The wood waste ranges in size from sawdust and chips to timber. Potentially, the larger debris could be burned as fuel at the NSP Bayfield Power Plant located in Ashland. Some additional maintenance at the plant would be required to accommodate the wood debris but this is considered a viable option at this time.

Ancillary Solid Wastes

Waste such as personal protective equipment (PPE), construction debris and other types of solid wastes generated during the conduct of remedial activities can be disposed of at a local municipal landfill. This management method will be used in all remedial alternatives. The quantity generated will depend on the remedial alternative. Personal protective equipment (PPE) will be evaluated and handled in accordance with USEPA guidance document to handle investigation derived waste (USEPA 1992).

4.2.5 Monitoring

The magnitude and nature of monitoring will depend upon the alternative selected. Monitoring can include verification monitoring to verify remediation objectives are met, operation and maintenance monitoring of disposal sites, or long-term monitoring to verify achievement of RAOs. As part of the Feasibility Study and Remedial Action Plan, the following monitoring programs will be developed:

- Baseline Monitoring
- Implementation Monitoring
- Verification Monitoring
- Operations and Maintenance Monitoring
- Long-term Monitoring

Specifics of these monitoring programs will be developed once an alternative has been selected. A summary of monitoring programs anticipated for various alternatives is presented along with the discussion of each specific alternative in Section.4.5.

4.3 Development of Remedial Alternatives for Sediment

This section describes the development of alternatives based on the evaluation of process options described above, and sets forth costs associated with each alternative.

As part of the three removal and containment alternatives (Alternatives SED-2, SED-3, and SED-4) monitored natural recovery (MNR) would be used to prevent access to areas where some risk could remain during remedial action, and to evaluate the impact of remedial actions with respect to reduction of risk through natural processes.

Monitored natural recovery relies upon naturally occurring processes to contain, reduce, or eliminate the toxicity or bioavailability of sediment contaminants. These processes may include burial of contaminants by continued sedimentation or degradation of contaminants by biological, chemical or other natural processes. As implied by its name, monitored natural recovery also includes acquisition of information on the effectiveness of these natural processes over time to verify that risk due to sediment contaminants is decreased.

In comments to the RAO Technical Memorandum, USEPA directed that "sediments exceeding 5.6 µg PAH/g dwt will be monitored to assure that there are no unacceptable impacts to the benthic community and that the levels of PAHs in the surface sediments to which the benthic [sic] is exposed decreases over time to [5.6 µg PAH/g dwt]". Furthermore, USEPA directed that, "the Remedial Action Plan will include specific performance objectives for monitoring Site sediments in the concentration range from 5.6 µg PAH/g dwt to 9.5 µg PAH/g dwt" and that "the Remedial Action Plan will include contingencies that will be implemented if the performance objectives for Natural Recovery of these sediments to levels lower than [5.6 µg PAH/g dwt] does not occur."

Thus, monitoring of natural recovery will be a component of all sediment alternatives.

The cost estimates presented in the following sections are preliminary since results of the treatability studies are not yet available. However, relative cost estimates for the three sediment alternatives should allow comparison since they were developed from the same information.

4.3.1 Alternative SED-1: No Action

The no-action alternative was retained as a baseline against which other technologies are compared. The no-action alternative assumes no cleanup or long-term monitoring, and is not expected to meet the RAOs. No action requires no planning, maintenance, or monitoring. Under this alternative, it is anticipated that natural mechanisms, such as dispersion, biodegradation, etc., would eventually reduce concentrations of VOC and PAH and NAPL; however, no monitoring would be performed to determine if these mechanisms are indeed taking place, nor would any method of evaluating potential risk to human health and the environment be enacted.

4.3.2 Alternative SED-2: Sediment Containment within a Confined Disposal Facility

Alternative SED-2 would consist of sediment removal and disposal, and containment within a CDF combined with IC and MNR. This alternative is illustrated in Figure 4-1and consists of the following components:

1) Determine the area of sediment containing significant wood debris and NAPL material to be covered by and contained within a CDF;

2) Construct CDF around pre-determined area;
3) Remove sediment containing concentrations of PAH greater than 9.5 ug PAH/g dwt at 0.415% OC located outside the CDF footprint and place within CDF area; and
4) Monitor sediment areas outside of CDF where concentrations of PAH greater than 5.6 µg PAH/g dwt at 0.415% OC have been observed.

Contaminated sediment and soil from portions of the Site that are not included in the footprint of the CDF would be removed by dredging or excavation and placed within the CDF. Once the CDF is constructed, long-term monitoring of sediment where concentrations of PAH greater than 5.6 µg PAH/g dwt at 0.415% OC have been observed would be performed. The objective of the long-term monitoring will be to evaluate the effectiveness of the CDF relative to preventing migration of contaminants to areas where exposure could occur, and to monitor the affect of natural recovery of areas outside of the CDF.

Since this alternative will involve filling of the nearshore area to elevations above the lake level, it would result in permanent loss of shallow water lake bed. As a result compensatory mitigation for wetland loss would be required.

Equipment that will be used for implementation of this alternative includes:

- Dredging equipment – for removing sediment from the lakebed
    - Hydraulic
    - Mechanical
- Excavation equipment – for construction of portions of the CDF and dewatering basins
    - Traditional
    - Long-stick
- Transportation equipment – for moving sediment from the dredge to the CDF
    - Barge
    - Piping
- Monitoring equipment – to evaluate effectiveness of remedy
    - Groundwater monitoring wells
    - Piezometers for water level measurements
    - Sediment sampling devices
    - Surface water sampling devices

4.3.2.1 Concept and Rationale for the CDF

<u>Concept</u>

A CDF alternative would meet the sediment RAOs at substantially less cost than anticipated for the other alternatives. This remedial alternative is designed to avoid the potential risks due to volatilization of VOCs during debris removal and dredging and excavation of sediment and soil. The CDF would be designed to cover most the areas of the offshore sediment that are impacted by NAPL and substantial volumes of wood debris. Sediment with unacceptably elevated levels of

SVOCs and VOCs, including NAPL, as well as areas on upland portions of the Site that are impacted by wood material mixed with coal tar wastes, would remain in place and be incorporated into the CDF.

The design of the CDF would be compatible with the recreational nature of the nearshore area and incorporate features that will enhance both recreational use of the area as well as wildlife usage. Figures 4-2 and 4-3 illustrate this concept.

The CDF would be constructed over approximately six acres of lake bed and 13 acres of upland. The elevation at the lake boundary will be approximately 609' NGVD in order to prevent wave overtopping. The top of the CDF would be fairly level, although there would be a provision for drainage and "blending" with upland topography.

As conceived, there would be open areas designed as grassland habitat and managed for wildlife, and other areas designed and managed for recreational use by the public, i.e., boaters, fishers, birdwatchers, etc.

There would also be the option for the City of Ashland to incorporate elements of an expanded marina similar to those envisioned in the Ashland Waterfront Development Plan.

Rationale and Precedent

A comprehensive discussion on the use of CDFs for disposal of contaminated sediments and precedent for CDFs in the Great Lakes by Dr. Mike Palermo is provided in Attachment 3. CDFs are one of the most commonly considered alternatives for contaminated sediments from navigation projects and are also an option commonly considered and more recently used for disposal of contaminated sediments dredged for purposes of sediment remediation (USACE 2003, USEPA 2005).

Design of CDFs has evolved over the years based on research and field experience. CDFs have combined design features and processes common to wastewater treatment, landfills, dams, and breakwaters. The designs for existing CDFs in the Great Lakes focused primarily on retention of sediment solids and physical stability of the dikes in the high-wave and ice-prone environment of the Great Lakes. In-water CDFs in the Great Lakes, (e.g., Duluth-Superior Harbor - Erie Pier) have dikes that resemble a breakwater made of stone, gravel and other materials. Large armour stones are typically placed on the outside face of the dike to protect against the erosive effects of waves. The inner core of the dike is often constructed with sand and gravel, sometimes in discrete layers. The dike, which is permeable, encircles the disposal area where the dredged material is placed. The sediment particles and contaminants bound to the particles settle out in the disposal area and excess water passes back through the dike. As the facility becomes filled, the dikes become less permeable, and water must be removed by overflow weirs, filters in the dikes, or pumping. Upland CDFs are designed with earthen dikes that resemble a levee or berm. The dikes are most often constructed with soil excavated from the disposal site, and the sides seeded to prevent erosion (Miller 1998).

Development of a comprehensive technical basis for CDF design aspects related to management of contaminated sediments began in the mid-1970s with the USACE research programs initially authorized by the River and Harbor Act of 1970 (P.L.91-611). These efforts included evaluation of sedimentation and consolidation processes in CDFs; weir design; CDF effluent and leachate control; equipment and techniques for dewatering and reclamation; and beneficial reuse of material in CDFs. The first guidelines for designing, constructing, and managing (CDFs) to maximize service life and minimize adverse environmental impacts were developed (Palermo, Montgomery, and Poindexter 1978), and these guidelines were subsequently updated and expanded in the USACE Engineer Manual *Confined Disposal of Dredged Material* (USACE 1987).

USACE and USEPA subsequently developed a Technical Framework for dredged material management (USACE 2004) that included full consideration of CDF contaminant transport pathways and controls, and developed a supporting sediment testing manual that provided detailed testing and evaluation procedures for CDF contaminant pathways (USACE 2003). An expanded Engineer Manual *Dredging and Dredged Material Management* (USACE in publication) has also been developed that will include guidance on design of contaminant control measures for CDFs. Collectively, these developments have resulting in a comprehensive technical basis for design of CDFs used for placement of contaminated sediments resulting from both navigation and sediment remediation projects.

Field experience and the availability of technically-based design procedures for CDF contaminant pathway evaluations and controls has led to increased consideration and use of CDFs for a number of sediment remediation projects – over 40 have been constructed on the Great Lakes alone (USACE 2003). As a result, USEPA recognized CDFs as an option for disposal of contaminated sediments at CERCLA sites in its Contaminated Sediment Remediation Guidance for Hazardous Waste Sites (USEPA 2005):

"CDFs are engineered structures enclosed by dikes and specifically designed to contain sediment. CDFs have been widely used for navigational dredging projects and some combined navigational/environmental dredging projects but are less common for environmental dredging sites, due in part to siting considerations. However, they have been used to meet the needs of specific sites, as have other innovative in-water fill disposal options, for example, the filling of a previously used navigational waterway or slip to create new container terminal space (e.g., Hylebos Waterway cleanup and Sitcum Waterway cleanup in Tacoma, Washington). In some cases, new nearshore habitat has also been created as mitigation for the fill."

4.3.2.2 Mobilization/Demobilization, Site Preparation and Miscellaneous Activities

Mobilization will include transportation and erection of all dredge and crane equipment This will include any piping set up and barges mobilized to the site. The cost also includes site preparation which includes moving or abandonment of any existing utilities and provision of electrical power, adding a site security fence in the work areas and any pre-trenching that may be needed.

Demobilization will include the teardown and removal of all of the equipment. Miscellaneous activities include preparing a Health and Safety Plan (HASP), health and safety personnel monitoring and construction oversight.

4.3.2.3 Construction of CDF

CDF construction would include driving the sheet pile wall to separate the areas inside not to be dredged and the outside area planned for dredging area as well as on land as described in Section 4.2.2.2. A barge mounted pile driver will be used for the in water locations. The design is intended to contain all of the sediment and groundwater in a water tight enclosure. On the lake side of the wall a protective stone dike will be constructed. The extent of this armored dike will be determined in Remedial Design. Other items included in the construction are placement and disposal of the hydrocarbon booms along the inside perimeter of the water area to collect the NAPL that may be released during dredging and placement activities.

4.3.2.4 Sediment Removal

Sediment removal under this alternative is less complex because a design objective for the CDF is that it will cover most of the areas that contain large wood debris and NAPL. This will avoid the need for the substantial majority of debris removal and with it the potential for release of VOCs. Removal of sediment outside of the footprint of the CDF under this alternative likely will be accomplished with a hydraulic dredge. Although this will result in a need to treat substantially more dredge water, hydraulic dredging will minimize volatilization and resuspension. Some modern hydraulic dredges should be able to achieve 20% solids content (v/v) with careful control when dredging in areas that are relatively debris-free.

Under this alternative, volatilization associated with dredging and dredge material dewatering may be an issue, but it expected to be less than for Alternatives SED-3 and SED-4.

Areas outside of the footprint of the CDF with concentrations of tPAHs greater than 9.5 ug PAH/g dwt at 0.415% OC will be dredged and pumped directly to the CDF. Under this scenario approximately 74,000 CY would be dredged from areas outside of the CDF and disposed of in the CDF.

<u>*Performance Objectives for Dredging Residuals and Dredging-Related Resuspension*</u>

Dredging performance objectives will specify goals for residual concentrations of contaminants in surface sediments in areas that have been dredged. Typical performance objectives for dredging residual would be based upon the comparison of surface-weighted average concentrations (SWAC) to the sediment PRG. These performance objectives would specify whether re-dredging is necessary and in some cases when a thin layer cap would be applied to meet performance objectives.

Dredging performance objectives would also be developed for allowable rates of sediment resuspension during dredging, based upon water quality standards that are protective of ecological receptors and used for operational control of dredging. Typically, resuspension objectives are two or three-tiered and specify how dredging operations need to be modified if the action levels are exceeded.

Volatilization and Odor Control

If volatiles are released, they may disperse beyond the immediate vicinity of dredging operations and onshore treatment operations, depending upon ambient weather conditions (See Attachment 2). With the proximity of a relatively large population in Ashland, this presents the real possibility of unacceptable exposure unless it is possible to design engineering controls.

Controls for minimization of volatile releases are available for onshore operations; however, volatilization control for operations on the water would have to be investigated further during a pilot scale project, since tenting over working dredges on the water is difficult and would add complexity to maintaining efficient dredge production rates.

It is likely that remedial construction workers would have to use Class C PPE.

Silt Curtains and Hydrocarbon Booms

Engineering controls for minimizing release and dispersal of dissolved or free phase contaminants to water beyond the Site are well developed and would likely consist of redundant turbidity barriers and booms. Temporary sheet piling will also be considered if redundant turbidity barriers and booms are not effective. This aspect of a dredging remedy can also be evaluated and optimized though a pilot scale project.

4.3.2.5 Sediment Dewatering

Prior to dewatering, the dredge material will be processed to separate wood from sediment. This can be achieved through processes that separate sediment by screening, gravity settling, and floatation. Screening would likely take place on the dredge if the material is mechanically dredged and hydraulically transported to the CDF. No other dewatering will be needed except for dredge dewatering of the debris stockpile in the barge before placing debris in the dumpster for disposal.

4.3.2.6 Water Treatment

Water treatment potentially would include addition of polymers and alum to help settle fine particles in the CDF. Water would be pumped off at a rate equal to the sediment placement into the CDF. The system would include pumping the clear water near the surface of the CDF to a sand filter or other cartridge filters, an oil/water separator and through an activated carbon bed. The treated water meeting the substantial requirements of an NPDES permit would be discharged to Lake Superior or to the WWTP. The cost for water treatment also includes operating a skimmer in the CDF to control any floating NAPL.

As an alternative to direct placement of sediments in the CDF after mechanical dredging, hydraulic transportation from the mechanical dredged sediments may be considered. This would include a screen on a hopper at the dredge that would discharge to a high solids slurry pump. Here make-up water that is pumped from CDF after settling would be and mixed with the sediments to 15%-20% solids level and hydraulically conveyed in a hose through a discharge nozzle into the CDF. This nozzle could be a treme' type design to minimize velocity at the discharge and also minimize suspension of fines in the CDF water. The treme' would allow more controlled placement and help reduce water settlement treatment in the CDF due to lower fines in the water caused during sediment placement. An estimated flow of about 40 million gallons will be re-circulated to the dredge using only settlement and polymer treatment in the CDF prior to pumping back to the dredge. Approximately 14.9 million gallons will get fully treated and discharged to the lake or sewer system. This discharge volume is about the same volume for both placement methods.

4.3.2.7 CDF Closure

Closure of the CDF after all dredging is complete will include construction of a CDF cap. This includes placing a two-foot sand cap on the dredged sediments to begin the consolidation process. The cap will be placed in one foot lifts to allow even loading. After sufficient consolidation to obtain strength, additional sand will be placed in areas that are lower due to differential settlement. A geotextile drainage layer will be added, followed by a two foot compacted clay layer underlying a 40 mil HDPE liner. Drainage wells or wicks will be used to continue water removal during additional consolidation from the drainage layer below the HDPE liner. Another geotextile drainage layer will be added above the HDPE liner to collect the storm water seepage. A two-foot compacted layer additional foot of fill (sand) will then be placed on top of the HDPE liner with an overlying layer 0.5 ft top soil that will be seeded for grass.

On the land side of this cap in Kreher Park to the Marina Drive, the cap will be designed to meet the requirements of a RCRA Class C or D landfill and will be vegetated or paved on top. As discussed in Section 4.2.2.2 up gradient groundwater will be passively diverted around the CDF through use of drainage tiles, etc. This includes discharges to storm drainage systems that would be a part of the hydraulic control plan for the upland and sediment capping area. This may also include vegetation plantings and landscaping to enhance evapotranspiration and drainage from the bluff hillside.

4.3.2.8 Wetland Mitigation

Interaction with WDNR would be needed to identify appropriate mitigation/restoration projects to compensate for permanent loss of shallow water lake bed. Appropriate projects might include wetlands/river restoration, granting access across NSPW property adjacent to rivers or conveyance of land that has relevant environmental value. For purposes of this Technical Memorandum we will include an estimated cost of $1.5 million.

4.3.2.9 Monitoring

The magnitude and nature of monitoring will depend upon the alternative selected. Monitoring can include the following:

- baseline monitoring;
- implementation monitoring;
- verification monitoring;
- operation and maintenance monitoring; and
- long-term monitoring to verify achievement of RAOs.

As part of the Feasibility Study and Remedial Action Plan, the following monitoring programs would be developed.

Baseline Monitoring

Once RAOs are established and prior to implementation of the remedy, the database of information from all Site studies will be reviewed to ascertain whether an adequate statistical database is available to provide the basis for determining whether performance criteria are achieved. Based upon this review additional baseline sampling may be necessary.

Implementation Monitoring

Monitoring during implementation of the remedy will be conducted to ensure that remediation is being conducted in accordance with the Remedial Action Plan and that all project design specifications including performance of the contractor and environmental controls are met.

Verification Monitoring

Of particular importance to removal alternatives, verification monitoring determines whether performance criteria established for environmental media cleanup levels are met.

Operations and Maintenance Monitoring

Operations and maintenance monitoring will be required for any on site structures, e.g., CDFs, or continuing operations, e.g., hydraulic control, that are part of the Site remedy. This will verify continuing source control as well as ensure structures and/or control operations continue to perform as designed.

Long-term Monitoring

Long-term monitoring is primarily focused on verifying the continuing achievement of RAOs. It is of particular importance if any RAO is to be met through natural attenuation or natural recovery mechanisms. Generally, long-term monitoring is performed to ensure that the Remedial Action taken at the site continues to achieve RAOs. Contingency plans will be implemented in instances where expected results of remediation, RAOs, are not met.

4.3.2.10 Cost

The cost for this alternative is estimated at approximately $30,500,000. Various cost elements are summarized in Table 4-2.

Table 4-2 - Cost Summary – Alternative SED-2: CDF.

Task	Estimated Cost*
Mob/Demob & Miscellaneous	$2,298,000
Construct CDF	11,195,000
Dredge	9,696,000
Complete CDF	4,970,000
Compensatory Mitigation	1,500,000
Long Term Monitoring	800,000
Total Estimated Cost	**$30,459,000**

* Cost includes oversight and administration, engineering and contingency.

4.3.3 Alternative SED-3: Subaqueous Capping

Alternative SED-3 would consist of sediment and debris removal, subaqueous capping, dewatering, consolidation, and off site disposal with or without on site treatment, combined with MNR. The shallow nature of nearshore portions of the Site requires that some dredging be completed prior to capping so that the cap remains subaqueous and doesn't interfere with navigation or recreational boating. In addition, because of the location, the cap would have to be armored to resist erosion.

Costs estimates have been prepared for options under this alternative:

Alternative SED-3A: Mechanical Dredging, No Decontamination of Sediment
Alternative SED-3B: Mechanical Dredging, Thermal Decontamination of Sediment
Alternative SED-3C: Hydraulic Dredging, No Decontamination of Sediment
Alternative SED-3D: Hydraulic Dredging, Thermal Decontamination of Sediment

This alternative is illustrated in Figure 4-4 and consists of the following components:

1) Determine the area of sediment containing significant wood debris and free-phase material with concentrations of PAH greater than 9.5 ug PAH/g dwt at 0.415% OC;
2) Remove sediment in these areas to a depth of approximately four feet using one or more of the following means from barge-based or land-based platforms:
    a. hydraulic dredging;
    b. mechanical dredging; or
    c. excavation.
3) In areas where PAH levels do not exceed 9.5 ug PAH/g dwt at 0.415% OC at depths greater than approximately six feet, all sediment exceeding 9.5 ug PAH/g dwt at 0.415% OC will be removed.
4) Dewater dredged sediment on site using a settling pond and mechanical separation followed by on site treatment of sediment and liquid or off site disposal of sediment;
    a. If sediment is treated using LTTD, HTTD, or incineration it would be sent for off site disposal at a solid waste or other landfill after treatment;
    b. If sediment is not treated on site but only stabilized, it would be sent to a NR500 landfill for off site disposal;
    c. Water would be treated using flocculation, clarification, sand filtering, and carbon filtering and discharged to the Ashland WWTP. Alternatively it could be discharged directly to Lake Superior if it met DNR surface water criteria;
5) Construct subaqueous armored cap over dredged area; and
6) Monitor sediment areas outside of cap where concentrations of PAH greater than 5.6 μg PAH/g dwt at 0.415% OC have been observed.

Subaqueous capping would make use of a variety of materials, including some that would be reactive with site contaminants to contain or treat contaminants in situ. A properly designed cap would significantly decrease contaminant mobility and isolate the contaminants from the overlying water column and prevent exposure to ecological receptors or humans by covering the sediment.

Equipment that will be used for implementation of this alternative includes:

- Dredging equipment – for removing sediment from the lakebed
    - Hydraulic
    - Mechanical
- Excavation equipment – for construction of dewatering basins
    - Traditional
- Transportation equipment – for moving sediment from the dredge to the dewatering basins
    - Barge
    - Piping
- Dewatering equipment – for removing water from sediment prior to treatment or disposal
    - Settling ponds
    - Mechanical dewatering equipment
- Treatment equipment

  - LTTD
  - HTTD
  - Incinerator
  - Water treatment system
    - Flocculation
    - Clarification
    - Sand filtration
    - Carbon filtration
    - Oil/water separator
  - Solidification
- Disposal equipment
  - Piping to lake or WWTP for treated water
  - Transport to disposal location
    - Rail
    - Truck
    - Barge
- Monitoring equipment – to evaluate effectiveness of remedy
  - Groundwater monitoring wells
  - Piezometers for water level measurements
  - Sediment sampling equipment
  - Surface water sampling equipment

4.3.3.1 Concept and Rationale for Subaqueous Capping

Concept

The subaqueous capping alternative was selected for consideration because implementation of this alternative would meet the RAOs through capping of sediment that poses risk to human health and the environment. The cap would be designed to prevent access to impacted sediment with concentrations greater than 9.5 ug PAH/g dwt at 0.415% OC, as well as minimize migration of VOCs and SVOCs from within the sediment to surface water and unimpacted areas.

As previously stated, up to four feet of debris and sediment would be removed from the cap area to maintain the navigability of the submerged area to allow continued use as a recreational area and promote recruitment of aquatic organisms. Figure 4-5 illustrates the implementation of a cap over sediment.

The subaqueous cap would be constructed over approximately six acres of lake bed. Following construction, there would be no restrictions on usage of the capped area.

Rationale and Precedent

Subaqueous capping reduces risk associated with impacted sediment by eliminating the possibility of contact with sediment through removal and containment. In order to allow continued use of the area for water recreation, sufficient thickness of sediment would be removed to allow the cap to be placed without changing the elevation of the lake bottom in the area being capped.

Subaqueous caps have been constructed at numerous locations across the U.S.

4.3.3.2 Mobilization/Demobilization, Site Preparation, Site Restoration and Miscellaneous Activities

Mobilization/demobilization includes all the equipment needed for dredging, capping, and water treatment. This is estimated to be 5% of the remedial costs. Also included are pre and post bathymetric surveys and turbidity curtains across the bay to contain the dredging area. The miscellaneous activities include the preparing the HASP, health and safety personnel monitoring and construction oversight. Site restoration includes placing six inches of clean sediment on areas outside that are dredged outside the capped area.

4.3.3.3 Sediment Removal

Under this alternative, sediment overlying areas with large quantities of wood debris and areas containing NAPL would be dredged to a depth of approximately four feet. All sediments above the PRG in areas where levels of PAHs greater than 9.5 ug PAH/g dwt at 0.415% OC are not found deeper than six feet. This would allow placement of a subaqueous cap without interfering with navigation.

Sediment removal under this alternative would be conducted with excavators, mechanical dredges and hydraulic dredges. As discussed in Section 4.2.3, excavators and/or mechanical dredges would be used to remove debris from the targeted areas. In some places near shore, caissons could be constructed to enable dewatering, which would allow use of shore-based excavators to remove sediment. The efficacy of this latter approach will be determined during a pilot scale project.

After removal of debris, hydraulic dredges would be employed to dredge sediments above the PRG as described above. The dredge slurry will be pumped to an on-shore dewatering and treatment facility. Engineering controls likely will need to be implemented to minimize volatilization of VOCs during dredging. As previously discussed this can best be evaluated during a pilot scale project.

Performance objectives for dredge residuals and resuspension and control of volatilization and odour would be as discussed for Alternative SED-2 (Section 4.3.2.4).

4.3.3.4 Sediment Dewatering

Dewatering includes screening operations to remove large wood debris and operation of the plate and frame filter presses for dewatering prior to final sediment treatment. Also included is about a

4 acre pond system and stockpile area built at Kreher Park area with a lined earthen dike. Costs are included in the sediment treatment category discussed later. Volumes of dredged sediment slurries are estimated to be 13,000,000 gallons for mechanical dredging and 80,000,000 gallons for hydraulic dredging. No VOC controls have been included in costs at this time. However, based upon the results of the treatability studies they may be needed due to the naphthalene and benzene emissions. This will be discussed later in the FS when all of the treatability testing and modeling results are available.

4.3.3.5 Water Treatment

Water treatment includes sand filtration, oil/water separators, carbon filtration and related testing for O&M and discharge. Discharge will be to the Lake Superior or City of Ashland sewer system. Quantities range from about 5,200,000 gallons under mechanical dredging options to 69,300,000 gallons for hydraulic dredging. Costs for this are included in the sediment treatment category discussed later. Most of the systems are closed and should have minimal impact on air emissions or have cost controls.

4.3.3.6 Sediment Treatment

Sediment treatment includes either stabilization for direct landfill disposal, or as a contingency, thermal treatment to destroy the organics before land filling. Both processes have the potential to create some emissions in handling the dewatered sediment feed to the systems. This potential is likely much lower emissions than the dewatering operations unless there is an upset in the operations. The sediment treatment volumes are the same for all mechanical and hydraulic dredging options since they would all achieve the same dewatered feed volume of approximately 38,000 cy. The volume and weight after treatment is higher for stabilization since the process would add 10% more weight. Weight is estimated at 58,000. On the other hand thermal treatment which would reduce the water weight and not add material. This process would generate approximately 34,000 tons for disposal. HTTD was assumed to be the most cost effective thermal method and is the basis for the cost estimates. However additional design testing would be needed to evaluate this choice.

Sediment treatment includes the process of either stabilization for direct landfill disposal or thermal treatment to destroy the organics before land filling. Both processes have the potential to create some emissions in handling the dewatered sediment feed to the systems. There are likely much lower emissions associated with sediment treatment than with the dewatering operations unless there is an upset in the operations. The sediment treatment volumes are the same for all mechanical and hydraulic dredging options since they would all achieve the same dewatered feed volume of 37,258 cy. The volume and weight after treatment is higher for stabilization since it would add 10% more weight. There would result in approximately 57,539 tons for disposal compared to thermal treatment which would result in approximately 33,999 tons for disposal. HTTD is assumed to be the most cost effective thermal method and is the basis for the cost estimates. However additional design testing would be needed to evaluate this choice.

Sediment handling costs that include sediment dewatering, water treatment and sediment treatment are shown in Table 4-3. The major differences in cost are due to water treatment costs for hydraulic dredging and difference in stabilization versus thermal treatment costs.

4.3.3.7 Sediment Disposal

The disposal process will include the loading of sediment following drying and treatment/stabilization at the Site, and transportation to a commercial/industrial landfill. Several scenarios were evaluated for this option, assuming a sediment quantity of 78,000 cy based upon the sediment PRG. For purposes of cost estimation it is assumed one cubic yard of sediment will weigh 1.5 tons.

Truck transport to Seven Mile Creek landfill, Eau Claire, WI.

Under this scenario, sediment will be loaded into trucks and transported 125 miles to this facility for disposal. This alternative is the basis for disposal options cost estimates.

Barge and truck transport to K & W landfill, Ontonagon, MI

Under this scenario, sediment will be loaded on to barges in Ashland and transported via Lake Superior to Ontonagon, MI. Upon arrival in Michigan the sediment would be off-loaded to trucks for transport the remaining distance (20 miles) to the landfill. A typical barge has a capacity of approximately 1,500 tons, roughly the capacity of 100 trucks. Cost estimates include costs for improvements to the dock areas in Ashland and Ontonagon to facilitate loading and unloading of the sediment.

Rail transport to Cranberry Creek landfill, Wisconsin Rapids, WI

The third scenario evaluated assumes the sediment is loaded onto rail cars and transported to the Cranberry Creek landfill, Wisconsin Rapids, WI. Since the rail spur at the site is no longer connected to the main line, sediment would need to be loaded into trucks and transported elsewhere in Ashland and loaded on to rail cars. Rail service is available within the industrial park within Ashland, and estimated distance of five miles from the site. Sediment would then be transported via rail to the landfill in Wisconsin Rapids. Rail car capacity for estimation purposes is 100_tons. A train comprised of 50 cars would be able to transport 5,000 tons, roughly equal to 250_truck loads. Cost estimates include costs for improvements to the rail loading facility to facilitate transfer from the trucks directly to the rail cars.

Other Disposal Alternatives

As previously discussed, NSPW also may initiate siting of a ch. NR 500 landfill in the Ashland area for solid materials removed from the Lakefront Site. This disposal option is dependent on the material volume. The detailed analysis of this option will be included in the FS.

Wood Waste

There is the potential for generating a substantial quantity of wood waste if sediments are removed. The wood waste ranges in size from sawdust and chips to timber. Potentially, the larger debris could be burned as fuel at the NSP Bayfield Power Plant located in Ashland. Some additional maintenance at the plant would be required to accommodate the wood debris but this is considered a viable option at this time and will evaluated further in the FS.

Ancillary Solid Wastes

Waste such as personal protective equipment (PPE), construction debris and other types of solid wastes generated during the conduct of remedial activities can be disposed of at a local municipal landfill. This management method will be used in all remedial alternatives. The quantity generated will depend on the remedial alternative. Personal protective equipment (PPE) will be evaluated and handled in accordance with USEPA guidance document to handle investigation derived waste (USEPA 1992).

4.3.3.8 Subaqueous Capping

A subaqueous cap will be designed for placement over the area that has been dredged to four feet but still has sediments exceeding the sediment PRG. Dredging to four feet will provide sufficient depth for placement of an armored cap while not decreasing the lake bottom depth. Cap material considered in this application would be natural sand, organo-clays and/or carbon or other amendments to adsorb contaminants, and rock armoring to resist erosion.

The cap will consist of first installing a two layer organic clay liner over the area to be capped As an alternative a geotexile with activated carbon or bentonite sandwiched between a needle point punched mat may be installed. This will require first placing a 6-9 inch sand layer for protection from debris and levelling the surface. A three foot sand cover next would be placed over the area to be capped using a spreader barge, clam shell dredge or excavator on a barge. The sand cover would be added in 6-12" lifts to allow for consolidation of the underlying sediments to account for differential settlement. The sand cap would then provide containment and allow the sediments to gain strength and stability with the consolidation from the cap load. In areas where the water is less than six feet deep armoring using stone rip rap would be added for wave protection. A post capping bathymetric survey would be conducted to assure proper coverage and as a baseline for future measurements.

4.3.3.9 Monitoring

Monitoring options for this alternative would be the same as those listed in Section 4.2.2.9, with the exception that the monitoring plan would be geared toward monitoring the effectiveness of a subaqueous cap rather than a CDF.

4.3.3.10 Cost

The total cost for this alternative ranges from approximately $38, 321,000 to $59,223,000 depending upon whether the sediment is mechanically or hydraulically dredged and whether thermal treatment is needed. Cost elements are summarized in Table 4-3

Table 4-3 -Cost Summary – Alternative SED-3: Dredge/Cap.

Task	**Estimated Cost***			
	SED-3A	**SED-3B**	**SED-3C**	**SED-3D**
	Mechanical Dredge - No Treatment	**Mechanical Dredge - Thermal Treatment**	**Hydraulic Dredge - No Treatment**	**Hydraulic Dredge - Thermal Treatment**
Mob/Demob & Miscellaneous	$3,630,000	$4,359,000	$3,899,000	$4,625,000
Dredge	5,015,000	5,015,000	4,956,000	4,956,000
Cap	11,281,000	11,281,000	11,281,000	11,281,000
Sediment Handling[1]	11,514,000	27,674,000	16,964,000	33,059,000
Transport and Disposal	5,681,000	4,102,000	5,681,000	4,102,000
Long Term Monitoring	1,200,000	1,200,000	1,200,000	1,200,000
Total Estimated Cost	**$38,321,000**	**$53,631,000**	**$43,981,000**	**$59,223,000**

* Cost includes oversight and administration, engineering and contingency.

1: Sediment handling includes screening, dewatering, treatment and/or stabilizing if necessary.

4.3.4 Alternative SED- 4: Removal

Alternative SED-4 would consist of removal, dewatering, consolidation, and off site disposal with or without on site treatment, combined with MNR. Under this alternative, the greatest amount of sediment would be removed, treated and disposed of. This alternative, illustrated in Figure 4-6, consists of the following components:

1) Determine sediment with concentrations of PAH greater than 9.5 ug PAH/g dwt at 0.415% OC;
2) Remove these sediments using one or more of the following means from barge-based or land-based platforms:
    a. hydraulic dredging;
    b. mechanical dredging; or
    c. excavation.
3) Dewater dredged sediment on site using a settling pond and mechanical separation;
4) Water would be treated using an oil/water separator, flocculation, clarification, sand filtering, and carbon filtering and discharged to the Ashland WWTP. Alternatively it could be discharged directly to Lake Superior provided it met WI surface water criteria;

5) Dewatered sediment would be stabilized and disposed off site in a NR500 landfill or treated on site using LTTD, HTTD, or incineration prior to off site disposal at a solid waste or other landfill; and
6) Monitor sediment areas outside of cap where concentrations of PAH greater than 5.6 μg PAH/g dwt at 0.415% OC have been observed.

Removal is technically feasible for the Site, although several issues would have to be addressed in the design of a dredging alternative, including potential release of free-phase product and dispersal and volatilization of VOCs during dredging activities, as well as management of dredging residuals and handling of a substantial amount of wood debris. Some aspects of the Site are more disposed to the use of mechanical dredges or excavators (e.g., debris removal), while other aspects favor hydraulic dredges, (e.g., capture of free phase and minimization of volatilization).

Costs estimates have been prepared for options under this alternative:

Alternative SED-4A: Mechanical Dredging, No Decontamination of Sediment
Alternative SED-4B: Mechanical Dredging, Thermal Decontamination of Sediment
Alternative SED-4C: Hydraulic Dredging, No Decontamination of Sediment
Alternative SED-4D: Hydraulic Dredging, Thermal Decontamination of Sediment

Equipment that will be used for implementation of this alternative includes:

- Dredging equipment – for removing sediment from the lakebed
  - Hydraulic
  - Mechanical
- Excavation equipment – for construction of dewatering basins
  - Traditional
- Transportation equipment – for moving sediment from the dredge to the dewatering basins
  - Barge
  - Piping
- Dewatering equipment – for removing water from sediment prior to treatment or disposal
  - Settling ponds
  - Mechanical dewatering equipment
- Treatment equipment
  - LTTD
  - HTTD
  - Incinerator
  - Water treatment system
    - Flocculation
    - Clarification
    - Sand filtration
    - Carbon filtration

    - Solidification
- Disposal equipment
    - Piping to lake for treated water
    - Transport to disposal location
        - Rail
        - Truck
        - Barge
- Monitoring equipment – to evaluate effectiveness of remedy
    - Groundwater monitoring wells
    - Piezometers for water level measurements
    - Sediment sampling devices
    - Surface water sampling devices

4.3.4.1 Concept and Rationale for Removal

Removal by dredging is generally the presumptive remedy for contaminated sediment if cost factors and/or risk factors don't result in other alternatives being favored. Removal of contaminated sediment with dredges or excavators has been successfully implemented at a number of contaminated sediment sites. However, as discussed in Section 4.2.3 Site characteristics at Ashland provide several unique challenges.

4.3.4.2 Mobilization/Demobilization, Site Preparation, Site Restoration and Miscellaneous Activities

The mobilization/demobilization includes all the equipment needed for dredging, capping, and water treatment. This is estimated to be 5% of the remedial costs. Also included are pre and post bathymetric surveys and silt curtains across the bay to contain the dredging area. The miscellaneous activities include preparation of the HASP, health and safety personnel monitoring and construction oversight. Site restoration includes placing six inches of clean sediment in areas that are dredged.

4.3.4.3 Sediment Removal

Under this alternative, sediments greater than 9.5 ug PAH/g dwt at 0.415% OC would be removed regardless of depth. In some areas, sediments as deep as ten feet would be removed. Sediment removal under this alternative would be conducted with excavators, mechanical dredges and hydraulic dredges. As discussed in Section 4.2.3, excavators and/or mechanical dredges would be used to remove debris from the targeted areas. In some places near shore, caissons could be constructed to enable dewatering near-shore areas, which would allow use of shore-based excavators to remove sediment. The efficacy of this latter approach will be determined during a pilot scale project.

Under this alternative, engineering controls would likely need to be implemented to minimize volatilization of VOCs during dredging. As previously discussed this can best be evaluated during a pilot scale project. During dredging operations, turbidity curtains and floating hydrocarbon booms would be deployed to minimize dispersal of suspended sediments or floating free phase.

Because this alternative would result in substantial changes to the bathymetry of the nearshore waters at the Site, approximately 30,000 of clean fill will have to be placed in the nearshore areas that were dredged deeper than approximately two feet to partially restore pre-dredge contours.

Performance objectives for dredge residuals and resuspension and control of volatilization and odour would be as discussed for Alternative SED-2 (Section 4.3.2.4).

4.3.4.4 Sediment Dewatering

Dewatering is similar to Alternative SED-3 and includes screening to remove large wood debris and operation of plate and frame filter presses for dewatering prior to final sediment treatment. Also included is about a four acre pond system and stockpile area built on the Kreher Park area built with a lined earthen dike. Costs for that are included in the sediment treatment category discussed later. Volumes of dredged sediment slurries are estimated at 21,900,000 gallons for mechanical dredging and 131,700,000 gallons for hydraulic dredging. No VOC controls have been included in costs at this time. However, they may be needed due to naphthalene and benzene emissions. Since the dredging and dewatering are greater volumes than in Alternative SED-3, the emissions will also be last longer. This will be discussed later in the FS when all of the treatability testing and modeling results are available.

4.3.4.5 Water Treatment

Water treatment is also similar to Alternative SED-3 and includes sand filtration, oil/water separators, carbon filtration and related testing for O&M and discharge. Discharge meeting the requirements of an NPDES permit will be to Lake Superior or the City of Ashland WWTP. Estimated treatment quantities range 8,900,000 gallons for mechanical dredging to 118,800,000 gallons for hydraulic dredging. Costs are included in the sediment treatment category discussed later. Most of the systems are closed and should have minimal impact on air emissions or have cost control.

4.3.4.6 Sediment Treatment

Sediment treatment is the same as Alternative SED-3, however the volumes are larger. Sediment treatment includes either stabilization for direct landfill disposal or as a contingency, thermal treatment to destroy the organics before land filling. Both processes have the potential to create some emissions in handling the dewatered sediment feed to the systems. This is likely much lower emissions than the dewatering operations unless there is an upset in the operations. The sediment treatment volumes are the same for all mechanical and hydraulic dredging options since they would all achieve the same dewatered feed volume of approximately 64,000 cy. The volume and weight after treatment is higher for stabilization (99,000 tons) since it would add 10% more

weight. Thermal treatment would reduce the water weight and with no added material would result in approximately 58,500 tons for disposal. HTTD is again assumed to be the most cost effective thermal method and is the basis for cost estimates for thermal treatment at this time. However additional design testing would be needed to evaluate this choice.
Sediment handling costs include sediment dewatering, water treatment and sediment treatment as shown in Table 4.4. Major cost differences are due to water treatment costs for hydraulic dredging and difference in stabilization versus thermal treatment costs.

4.3.4.7 Sediment Disposal

The disposal process under this alternative are the same as for Alternative SED-3 (Section 4.3.3.7). There is just more sediment to dispose.

4.3.4.8 Monitoring

Monitoring options for this alternative would be the same as those listed in Section 4.3.2.9, with the exception that the monitoring plan would be geared toward monitoring the potential exposure to residual materials.

4.3.4.9 Cost

The total cost for this alternative ranges from approximately $42,152,000 to $82,496,000 depending upon whether the sediment is mechanically or hydraulically dredged and whether thermal treatment is needed. Cost elements are summarized in.

Table 4-4 - Cost Summary – Alternative 4: Dredge All.

Task	**Estimated Cost***			
	SED-4A	**SED-4B**	**SED-4C**	**SED-4D**
	Mechanical Dredge - No Treatment	**Mechanical Dredge - Thermal Treatment**	**Hydraulic Dredge - No Treatment**	**Hydraulic Dredge - Thermal Treatment**
Mob/Demob & Miscellaneous	$4,775,000	$6,028,000	$5,451,000	$6,696,000
Dredge	8,426,000	8,426,000	8,426,000	8,426,000
Sediment Handling[1]	18,605,000	46,390,000	32,053,000	59,746,000
Transport and Disposal	9,776,000	7,058,000	9,849,000	7,058,000
Long Term Monitoring	570,000	570,000	570,000	570,000
Total Estimated Cost	**$42,152,000**	**$68,472,000**	**$56,349,000**	**$82,496,000**

* Cost includes oversight and administration, engineering and contingency.
1: Sediment handling includes screening, dewatering, treatment and/or stabilizing if necessary

4.4 Detailed Analysis of Remedial Alternatives

In the above section, alternatives for sediment were developed in accordance with CERCLA and NCP requirements as well as additional guidance documents available from the USEPA. In this section these alternatives are assessed against criteria specified in the NCP and USEPA guidance, as follows:

- Threshold Criteria
  - Overall compliance with human health and the environment
  - Compliance with ARARs

- Balancing Criteria
  - Long-term effectiveness and permanence
  - Reduction of toxicity, mobility and volume through treatment
  - Short-term effectiveness
  - Implementability
  - Cost

- Modifying Criteria (assessed after the public comment period)
  - State and Agency Acceptance
  - Community acceptance

4.4.1 Threshold Criteria

Of the nine CERCLA-defined FS evaluation criteria, two criteria are threshold criteria and must be met by each remedial alternative to be considered applicable and appropriate for the remedy. These include:

- overall protection of human health and the environment; and
- compliance with ARARs.

4.4.1.1 Overall Protection of Human Health and the Environment

Protection of human health and the environment is based on an evaluation of the remedial alternative's ability to be protective of human health and the environment. The evaluation focuses on how a specific alternative achieves adequate protection, and how site risks are eliminated, reduced, or controlled. Unacceptable short-term or cross-media impacts are also evaluated, if present.

This evaluation criterion provides a final check to assess whether each alternative provides adequate protection of human health and the environment. The overall assessment of protection draws on the assessments conducted under other evaluation criteria, especially long-term effectiveness and permanence, short-term effectiveness, and compliance with ARARs.

Evaluation of the overall protectiveness of an alternative should focus on whether a specific alternative achieves adequate protection and should describe how site risks posed through each pathway being addressed by the FS are eliminated, reduced, or controlled through treatment, engineering, or institutional controls. This evaluation also allows for consideration of whether an alternative poses any unacceptable short-term or cross-media impacts.

4.4.1.2 Compliance with ARARs and TBCs

Each remedial alternative is evaluated against ARARs to determine compliance. If there are ARARs that are not met by an alternative, either the alternative can not be selected or there may be a basis for justifying a waiver of the ARAR under CERCLA. The justification for a waiver should be discussed under this criterion.

A complete listing and discussion of ARARs and TBCs was presented in the ASTM. This evaluation criterion is used to determine whether each alternative will meet Federal and State ARARs (as defined in CERCLA Section 121) that have been identified in previous stages of the RI/FS process. The detailed analysis should summarize which requirements are applicable or relevant and appropriate to an alternative and describe how the alternative meets these requirements. When an ARAR is not met, the basis for justifying one of the six waivers allowed under CERCLA should be discussed.

<u>ARARs specific to Retained Alternatives</u>

Alternative SED-1 – No Action
There are no ARARs that pertain to the no-action alternative, since no action is taken.

Alternative SED-2 –CDF, Removal and MNR
Under Alternative SED-2, steps would be taken to minimize or eliminate potential exposure to impacted sediment by removing sediment where concentrations of PAH exceed the sediment PRG. ARARs and TBCs that would relate to this alternative include landfill siting requirements (Wisconsin Statutes Chapter 289), design requirements for construction of a CDF in water (NR 322), and permission from the State to build the CDF on state property. In addition, WDNR has indicated that this alternative would need approval from both the Governor and State Legislature

Construction of a CDF would include the placement of fill material and some type of structure to contain the fill on the bed of Lake Superior. There are several available procedural mechanisms which might be used to authorize such fill and structure placement.

Section 30.12 permit: State of Wisconsin Statute Section 30.12 addresses the deposit of "any material" or placement of "any structure" upon the bed of any navigable waterway. Section 30.12 provides that approval may be given by WDNR via issuance of either a general or individual permit. Section 30.12 also recognizes that special authorization may be granted by the Wisconsin Legislature. In correspondence dated March 30, 2007, WDNR staff have advised their interpretation of Section 30.12 limits the agency's ability to issue permits that authorize deposits to "small amounts of incidental fill when associated with other structures." The language of Section 30.12 does not contain such a limitation on WDNR's authority and the Company does not agree that the agency's authority is so limited. To the extent that authorization under Section 30.12 might be deemed necessary but not available to an aquatic CDF, this statutory requirement may be pre-empted as a process ARAR via CERCLA section 121 (e)(1) or on the basis that it improperly "restricts the range of options available to the EPA." See, United States v. Denver, City and County Of, 100 F.3d 1509, 1512 (10th Cir. 1996).

Legislative lake bed grant: We are aware of at least two aquatic CDFs that have been authorized in Wisconsin Great Lakes waters via legislative lake bed grant. Pursuant to its authority under Article IX, Section 1 of the Wisconsin Constitution, the Wisconsin Legislature may grant authority to utilize a portion of lake bed for purposes considered to be consistent with the public trust in those navigable waters. Such legislative lake bed grants have been made to authorize the CDF in the waters of Lake Michigan's Green Bay. Wisconsin Statute Section 13.097 provides that WDNR is to report to the Legislature the agency's view of whether the lake bed grant is consistent with protecting and enhancing a public trust purpose. A legislative lake bed grant can be made only to a municipality; thus, if this mechanism is used either the City or County of Ashland would likely be designated as the lake bed grantee. Because a legislative lake bed grant is a form of legislative action, signature by the Governor would also be required.

Board of Commissioners of Public Lands Lease: State of Wisconsin Statute Section 24.39 authorizes the Board of Commissioners of Public Lands (BCPL) to enter into long-term (50-year), renewable leases of submerged lake bed for various purposes, including "improvements to water navigation, construction of harbor facilities, and recreation." State of Wisconsin Statute Section 30.11(5) directs WDNR to advise BCPL of its view as to the consistency of the proposed lease and associated use with the public interest. The BCPL can enter into leases with either municipal or private parties; however, the lessee must be the riparian property owner. If this mechanism is used, the City of Ashland as riparian owner would likely be the lessee and such a lease may well be consistent with the City's harbor development plans. BCPL leases do not require legislative or gubernatorial approval.

In light of the number of mechanisms that might be utilized to authorize an aquatic CDF, it would be premature to eliminate this option or to deem it less viable than other options currently under consideration. Design specifications for the CDF would need to satisfy the substantive statutory, public interest and public trust requirements; however, it is possible that all of these mechanisms may be considered process ARARs and thus subject to the CERCLA § 121(e)(1) permitting exemption as the CDF would constitute an "on site" remedy as defined in 40 CFR § 300.400(e)(1).

Additional action may be required to meet air and surface water quality during dredging and dewatering operations. Furthermore, wetlands mitigation may be necessary as part of this alternative. Upon proper implementation of this alternative, ARARs would be met.

Attachment 1 summarizes the ARARs and TBCs that affect implementation of Alternative SED-2.

In addition to the ARARs and TBCs described above the design of sediment removal process and CDF will have from U.S. Army Corps of Engineers concurrence.

Alternative SED-3 – Removal, Treatment, Disposal, Capping, and MNR

Under Alternative SED-3, steps would be taken to minimize or eliminate potential exposure to impacted sediment by removing sediment to a depth of four feet where concentrations of PAH exceed the sediment PRG. Sediment removed would be dewatered and treated on site using thermal treatment, or dewatered and sent off site for disposal in a landfill. Sediment located outside of the capped area with concentrations of PAH greater than 9.5 ug PAH/g dwt at 0.415% OC would be monitored. Alternative SED-3 would be similar to Alternative SED-2 with respect to ARARs. As with Alternative SED-2 WDNR has indicated that this alternative would need approval from both the Governor and State Legislature.

A subaqueous cap probably would also be considered a structure and fill on the bed of Lake Superior and would be subject to the same ARARs as Alternative SED-2. As with Alternative SED-2 there are several available procedural mechanisms which might be used to authorize such fill and structure placement. These are discussed in the previous section. In this regard, we are aware that USEPA and WDNR have proposed a ROD change for the Fox River NPL Site that includes capping of sediment in navigable waters. It is possible the mechanism upon which this decision is based can be used for the Ashland Site.

In addition, consideration of requirements for high-temperature thermal desorption units may be required (NR 400 through 499) if it is determined that the sediment needs to be decontaminated. Dewatering would be subject to WPDES requirements (NR 200 and NR 220 through 297). Upon proper implementation of this alternative, ARARs would be met.

Attachment 1 summarizes the ARARs and TBCs that affect implementation of Alternative SED-3.

In addition to the ARARs and TBCs described above the design of sediment removal process will have U.S. Army Corps of Engineers concurrence.

Alternative SED-4 – Removal, Treatment, Disposal and MNR

Under Alternative SED-4, steps would be taken to minimize or eliminate potential exposure to impacted sediment by removing sediment where concentrations of PAH exceed the sediment PRG Sediment removed would be dewatered and treated on site using thermal treatment, or dewatered and sent off site for disposal in a landfill. Treated sediment would be sent off site for beneficial reuse. Alternative SED-4 would be similar to Alternative SED-3 with respect to ARARs.

Attachment 1 summarizes the ARARs and TBCs that affect implementation of Alternative SED-4.

In addition to the ARARs and TBCs described above the design of sediment removal process will have U.S. Army Corps of Engineers concurrence.

4.4.2 Balancing Criteria

Five of the remaining criteria are referred to as balancing criteria by which the alternatives are compared and upon which the analysis is based. These include:

- long-term effectiveness and permanence:
- reduction of toxicity, mobility, or volume;
- short-term effectiveness;
- implementability; and
- cost

4.4.2.1 Long Term Effectiveness and Permanence

Each remedial alternative is evaluated as to magnitude of long-term residual risks, adequacy of controls, and reliability of long-term management controls in restoring impacted site media. Table 4-5 presents an evaluation of the long-term effectiveness and permanence of each alternative.

Table 4-5 - Evaluation of Long-term Effectiveness and Permanence for Potential Remedial Alternatives for Sediment

Alternative	Magnitude and Type of Residual Risk	Adequacy and Reliability of Controls
Alternative SED-1: No Action	Potential risk to human health or the environment, if any, would not be reduced.	There are no remedial actions or controls associated with this alternative.
Alternative SED- 2: CDF, Removal, and MNR	Risk to human health and the environment would be reduced through covering impacted material above the sediment PRG or placement of impacted sediment above the sediment PRG into the CDF area, and covering the CDF by placing clean material over the impacted sediment to prevent human contact and impact to biota. Monitoring would evaluate the effectiveness of the CDF in containing contaminated sediments and the effect of natural recovery processes that could result in reduction of COPC concentrations outside of the CDF footprint.	Alternative SED-2 would involve technologies that have been used previously, and whose adequacy and reliability have been tested. Control measures would be required when dredging and placing sediment into the CDF area to prevent or minimize transport of sediment outside of the area of concern. Similarly, impacts to air quality could occur, and may need to be addressed to prevent exposure to workers and downwind receptors. Placing clean material over the CDF would prevent exposure to sediment, and minimize on-going release of volatiles to water and air. Long-term monitoring would be required to evaluate the effectiveness of the CDF in preventing exposure to contaminants and containment of contaminated sediments.
Alternative SED-3: Removal, Treatment and/or Disposal, Capping, and MNR	Risk to human health and the environment would be reduced through removal of impacted sediment to allow sufficient draft to construct a cover, and constructing a cap over the remaining impacted sediment to prevent human contact and impact to biota. Removed sediment would be treated on site and/or disposed off site, thereby eliminating any potential risk associated with the sediment. Monitoring would evaluate on-going risk to human health and the environment from failure of the cap as well as the effect of natural recovery processes that could result in reduction of COPC concentrations beyond the cap area.	Alternative SED-3 would involve use of technologies that are proven reliable and accepted, including dredging, sediment capping, and treatment of sediment through incineration or thermal destruction, and off site disposal. Control measures would be required to ensure that exposure is limited during sediment removal, dewatering, treatment, and transport activities. These control measures could include placement of silt curtains and sorbent booms, and if necessary temporary sheet piling, during dredging operations, vapor recovery during dewatering and treatment operations, and special handling of waste, if necessary, during transport for disposal. If properly implemented, there would be little risk associated with implementation of this alternative although nearby residents may experience increased exposure to VOCs during dredging and on-shore sediment treatment operations. Monitoring would be required to evaluate the long-term effectiveness of these measures in preventing unacceptable exposure and risk.

Alternative	Magnitude and Type of Residual Risk	Adequacy and Reliability of Controls
Alternative SED-4: Removal, Treatment and/or Disposal and MNR	Risk to human health and the environment would be reduced through removal of impacted sediment, thereby preventing human contact and impact to biota. Since sediment removed would be treated on site and disposed off site, any potential risk associated with the sediment would be effectively eliminated. Monitoring would evaluate on-going risk to human health and the environment from impacted sediment that remains in place.	Alternative SED-4 would involve use of technologies that are proven reliable and accepted, including dredging, treatment of impacted sediment through incineration or thermal destruction, and off site disposal. Control measures would be required to ensure that exposure is limited during sediment removal, dewatering, treatment, and transport activities. These control measures could include placement of silt curtains and sorbent booms and if necessary temporary sheet piling, during dredging operations, vapor recovery during dewatering and treatment operations, and special handling of waste, if necessary, during transport for disposal. If properly implemented, there would be little risk associated with implementation of this alternative although nearby residents may experience increased exposure to VOCs during dredging and on-shore sediment treatment operations... Monitoring would be required to evaluate the long-term effectiveness of these measures in preventing unacceptable exposure and risk.

4.4.2.2 Reduction of Toxicity, Mobility or Volume through Treatment

The remedial alternatives are evaluated for permanence and completeness of the remedial action in significantly reducing the toxicity, mobility, or volume of hazardous materials through treatment. Each alternative is evaluated based on the treatment processes used, the volume or amount and degree to which it destroys or treats hazardous materials; the expected reduction in toxicity, mobility, or volume provided by the alternative; the extent to which the treatment is irreversible; and the types and quantities of residuals that will remain following treatment. Table 4-6 presents a summary of this evaluation.

Table4-6 Evaluation of Reduction of Toxicity, Mobility, or Volume through Treatment for Potential Remedial Alternatives for Sediment

Alternative	Treatment Process Used and Materials Treated	Volume of Material Destroyed or Treated	Degree of Expected Reductions	Degree to Which Treatment is Irreversible	Type and Quantity of Residuals Remaining
Alternative SED-1: No Action	No treatment process used.	None.	None.	Not applicable.	No treatment, therefore all residuals remain.
Alternative SED-2: CDF, Removal, and MNR	Auxiliary treatment for water will be necessary prior to discharge.	None treated, although over 74,000 cy of material would be placed and contained within CDF. Approximately another 60,000 cy would be covered by CDF. There would be no reduction in volume.	None, although exposure to contaminants is eliminated by containment within CDF.	Treatment via construction of a CDF would be nearly completely reversible.	No treatment, therefore all residuals remain; however, these residuals do not pose a risk to humans or biota as direct contact is effectively eliminated and the contaminated sediments are contained in a CDF.
Alternative SED-3: Removal, Treatment and/or Disposal, Capping, and MNR	Impacted sediment that is removed would be treated by thermal desorption or incineration, or shipped off site for disposal.	Approximately 78,000 cubic yards of material would be removed, treated and disposed.	Destruction efficiency of thermal treatment is anticipated to be 99% or more; material that remains in place would be effectively contained thereby eliminating risk to human heath and biota; material shipped off site for disposal would be effectively contained, thereby eliminating exposure.	Thermal destruction is permanent and irreversible; theoretically, untreated sediment that is sent for off site disposal could present potential risk; however, this scenario is unlikely.	Approximately 50,000 cubic yards of impacted material would remain in place; however, this material would be capped, thereby effectively eliminating risk to human health and biota.
Alternative SED-4: Removal, Treatment and/or Disposal and MNR	Impacted sediment that is removed would be treated by thermal desorption or incineration, or shipped off site for disposal.	Approximately 134,000 cubic yards of material would be removed, treated and disposed.	Destruction efficiency of thermal treatment is anticipated to be 99% or more.	Thermal destruction is permanent and irreversible.	Under this alternative, impacted sediment with PAH concentrations greater than the sediment PRG would be removed, thereby effectively eliminating risk to human health and biota.

4.4.2.3 Short Term Effectiveness

The evaluation of short-term effectiveness is based on the degree of protectiveness of human health achieved during construction and implementation of the remedy. Potential implementation risks to the community and site workers and mitigation measures for addressing those risks are included in this evaluation. In addition, environmental impacts during implementation and the time required to achieve the RAOs must also be considered in the evaluation of this criterion.

Table 4-7 summarizes the results of this evaluation.

Table 4-7 - Evaluation of Short Term Effectiveness for Potential Remedial Alternatives for Sediment

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
Alternative SED-1: No Action	Since no remediation is occurring, no protection of community and workers is necessary.	Since no remediation is occurring, there would be no additional impact to the environment over current impacts.	RAOs would not be achieved in the foreseeable future, and are unlikely to be met within 30 years.
Alternative SED-2: CDF, Removal, and MNR	Worker and community protection would be required and controls would need to be implemented during dredging, placement and dewatering of sediment and construction of the CDF.	Dredging and dewatering activities could release volatiles from sediment into surface water and air, thus impacting surface water and air quality. Dredging could agitate sediments, which could lead to resuspension and dispersal. Nearby residents may experience increased exposure to VOCs during dredging and on-shore sediment treatment operations.	It is anticipated that RAOs would be reached upon completion of the CDF; based on current volume estimates, it is anticipated to be completed within two years from project start.
Alternative SED-3: Removal, Treatment and/or Disposal, Capping, and MNR	Worker and community protection would be required and controls would need to be implemented during dredging, placement and dewatering of sediment and construction of the cap.	Dredging and dewatering activities could release volatiles from sediment into surface water and air, thus impacting surface water and air quality. Dredging could also agitate sediments, which could lead to resuspension and dispersal. Thermal treatment has the potential to release VOCs into the air during start-up or pilot operations until the unit is operating at optimal efficiency. Nearby residents may experience increased exposure to VOCs during dredging and on-shore sediment treatment operations. If sediment is disposed off site without treatment at a landfill there would be no future exposure to humans or biota because the access is controlled.	It is anticipated that RAOs would be reached upon completion of the cap and completion of thermal treatment; based on current volume estimates, it is anticipated to be completed within three years from project start.
Alternative SED-4: Removal, Treatment and/or Disposal and MNR	Worker and community protection would be required and controls would need to be implemented during dredging, dewatering, and treatment.	Dredging and dewatering activities could release volatiles from sediment into surface water and air, thus impacting surface water and air quality. Dredging could also agitate sediments, lead to resuspension and dispersal. Thermal treatment has the potential to release VOCs into the air during start-up or pilot operations until the unit is operating at optimal efficiency. If sediment is disposed off site without treatment, environmental liability is simply transferred to another location, thereby potentially impacting its new location. Nearby residents may experience increased exposure to VOCs during dredging	It is anticipated that RAOs would be reached upon completion of the dredging and thermal treatment; based on current volume estimates, it is anticipated to be completed within three years from project start.

Alternative	Protection of Community and Workers During Remediation	Environmental Impacts of Remedy	Time Until RAOs are Achieved
		and on-shore sediment treatment operations.	

4.4.2.4 Implementability

Implementability is based on the evaluation of technical feasibility, administrative feasibility, and the availability of services and materials. Technical feasibility considers the following factors:

- difficulties that may be inherent during construction and operation of the remedy;
- the reliability of the remedial processes involved;
- the flexibility to take additional remedial actions, if needed;
- the ability to monitor the effectiveness of the remedy;
- the availability of offsite treatment, storage, and disposal facilities; and,
- the availability of needed equipment and specialists.

Administrative feasibility considers permitting and regulatory approval and coordination with other agencies. Table 4-8 presents a summary of this evaluation.

Table 4-8 -Evaluation of Implementability of Potential Remedial Alternatives for Sediment

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
Alternative SED-1: No Action	There would be no technical issues associated with this alternative. The ability to complete additional investigation or remedial measures would not be prevented by this alternative.	Not applicable, since no technology is implemented. No monitoring would be conducted.	There would be no administrative issues related to the no-action alternative.	No services or materials would be needed for this alternative.
Alternative SED-2: CDF, Removal, and MNR	The technical aspects of this alternative, including dredging, placement and dewatering of sediment, and construction of a CDF, are all feasible technologies. Implementation of this alternative would not prevent completion of additional investigation or remedial measures. However, significant effort would be required to access impacted sediment in the CDF for additional evaluation or remediation.	The technologies and process options used as part of this alternative have been used elsewhere with success. Monitoring would allow accurate evaluation of effectiveness of remedial action through collection of samples outside and within the CDF to compare concentrations with pre-remedial action levels.	Administrative issues related to implementation of this alternative would include complying with ARAR requirements for dredging and construction of a CDF in navigable waters. According to WDNR, this alternative would need approval by the State Legislature and Governor, thus potentially making administrative implementability difficult.	Services necessary for this alternative are readily available and proven technologies. Companies that perform dredging, sheet-pile installation, and cover construction are located in relatively close proximity to the site.
Alternative SED-3: Removal, Treatment and/or Disposal, Capping, and MNR	The technical aspects of this alternative, including dredging, dewatering, treatment, and construction of a subaqueous cap, are all feasible technologies. Implementation of this alternative would not prevent completion of additional investigation or remedial measures. However, significant effort would be required to	The technologies and process options used as part of this alternative have been used elsewhere with success. Monitoring would allow accurate evaluation of effectiveness of remedial action through collection of samples outside and within the CDF to compare concentrations with pre-remedial action levels.	Administrative issues related to implementation of this alternative would include complying with ARAR requirements for dredging and construction of a cap in navigable waters, as well as operation of a treatment system at the site. According to WDNR, this alternative would need approval by the State	Services necessary for this alternative are readily available and proven technologies. Companies that perform dredging, sheet-pile installation, and sub-aqueous cap construction are located in relatively close proximity to the site. Thermal treatment units are transportable and can be readily transported to the site.

Alternative	Technical Feasibility	Reliability of Technology	Administrative Feasibility	Availability of Services and Materials
	access impacted sediment under the cap for additional evaluation or remediation.		Legislature and Governor, thus potentially making administrative implementability difficult.	
Alternative SED-4: Removal, Treatment and/or Disposal and MNR	The technical aspects of this alternative, including dredging, dewatering, treatment, and off site disposal, are all feasible technologies. Implementation of this alternative would not prevent completion of additional investigation or remedial measures.	The technologies and process options used as part of this alternative have been used elsewhere with success. Monitoring would allow accurate evaluation of effectiveness of remedial action through collection of samples outside and within the CDF to compare concentrations with pre-remedial action levels.	Administrative issues related to implementation of this alternative would include o complying with ARAR requirements for dredging as well as operation of a treatment system at the site. Furthermore, additional administrative actions could be required to meet the intent of ARARs.	Services necessary for this alternative are readily available and proven technologies. Companies that perform dredging, and thermal treatment are located in relatively close proximity to the site. Thermal treatment units are transportable and can be readily transported to the site.

4.4.2.5 Cost

For each remedial alternative, estimated capital, O&M, and periodic costs are prepared in accordance with the USEPA guidance document *A Guide to Developing and Documenting Cost Estimates During the Feasibility Study* (EPA and USACE, 2000). The cost estimates are developed primarily for the purpose of comparing remedial alternatives and not for establishing project budgets. The estimating process provides costs that are within a range of 30-percent below to 50-percent above expected actual costs, consistent with USEPA guidance. Present worth analyses are then performed on the cost estimates for each alternative for comparative purposes. A 30-year O&M period and a 7-percent discount rate are used to generate the present worth values, in accordance with USEPA guidance.

Annual O&M costs are estimated for each alternative independently. It is assumed that all work is contracted and the estimates do not account for possible economies of scale (i.e., completing all activities at the site that could be performed at the same time).

Table 4-9 presents a summary of the cost evaluation for all alternatives evaluated.

Table 4-9 Cost Summary of for Potential Remedial Alternatives for Sediment

Alternative	Estimated Cost
Alternative SED-2 - CDF	$ 30,459,000
Alternative SED-3A – Mechanical Dredge, Cap, No Treatment	$ 38,321,000
Alternative SED-3B - Mechanical Dredge, Cap, Thermal Treatment	$ 53,631,000
Alternative SED-3C – Hydraulic Dredge, Cap, No Treatment	$ 43,981,000
Alternative SED-3D – Hydraulic Dredge, Cap, Thermal Treatment	$ 59,223,000
Alternative SED-4A - Mechanical Dredge, No Treatment	$ 42,152,000
Alternative SED-4B - Mechanical Dredge, Thermal Treatment	$ 68,472,000
Alternative SED-4C – Hydraulic Dredge, No Treatment	$ 56,349,000
Alternative SED-4D – Hydraulic Dredge, Thermal Treatment	$ 85,496,000

4.4.3 Modifying Criteria

The third group, the *modifying criteria*, includes:

- State/Support agency acceptance; and
- Community acceptance.

As previously discussed, these last two criteria are typically formally evaluated following the public comment period, although they can be factored into the identification of the preferred alternative to the extent practicable.

4.5 Comparative Analysis of Alternatives

In this section, as required by CERCLA and NCP guidance a comparative evaluation is conducted. The advantages and disadvantages of the alternatives will be concurrently assessed with respect to each criterion. The criteria considered as part of this comparative evaluation were discussed in Section 4.4. Table 4-10 presents a summary of the comparative analysis.

Table 4-10 Summary of Comparative Analysis for Potential Sediment Remedial Alternatives

Criteria	Alternative SED-1: No Action	Alternative SED-2: Consolidation, CDF, and Monitoring	Alternative SED-3: Removal, Capping, Treatment and/or Disposal, and Monitoring	Alternative SED-4: Removal, Treatment and/or Disposal, and Monitoring
Overall Protection of Human Health and the Environment	Low	High	High	High
Compliance with ARARs and TBCs	Low	High	High	High
Long-term Effectiveness and Permanence	Low	Moderate	Moderate to High	High
Reduction of Toxicity, Mobility and Volume through Treatment	Low	Moderate	Moderate	High
Short-term Effectiveness	High	High	Moderate	Low
Implementability - Technical	Easy	Moderate	High	High
Implementability - Administrative	High	High	High	Moderate
Cost	Low	Moderate	High	High

4.5.1 Overall Protection of Human Health and the Environment

Alternative SED-1 – No Action – offers the least protection of human health and the environment, as no additional actions would be taken to address site issues.

Alternative SED-2 – CDF –assures protection of human health and the environment by eliminating access to impacted sediment. Under this alternative, there is no destruction of COPCs, but these materials are permanently contained and inaccessible to humans or biota, thereby reducing risk.

Alternative SED-3 – subaqueous capping of a portion of the sediment and removal of the remainder – is also protective of human health and the environment if the sediment is treated, because it isolates a portion of the sediment above the sediment PRG from exposure to humans or biota. The remaining sediment above the sediment PRG is removed. If that portion is thermally treated it reduces its volume and permanently eliminates its toxicity by treatment. If the sediment were to be sent for disposal without treatment, then this alternative it reduces in situ volume and eliminates exposure to humans and biota by transfer of these materials to an environment where access is controlled. There is no reduction in toxicity.

Alternative SED-4 – removal –is also protective of human health and the environment if the sediment is treated, because it results in decontamination of sediment above the PRG and removes it from the aquatic environment. If the sediment were to be sent for disposal without treatment, then this alternative would be roughly equivalent to Alternatives SED-2 and SED-3 (if Alternative SED-3 were also completed without sediment treatment); there would be no reduction in toxicity, but exposure to humans and biota is eliminated because access is controlled. There is no reduction in toxicity.

4.5.2 Compliance with ARARs and TBCs

Alternative SED-1 would not comply with regulations. Alternatives SED-2, SED-3, and SED-4 would be similar with respect to meeting ARARs and TBCs, as engineering and construction actions would be developed and completed in compliance with federal and state regulations.

4.5.3 Long-term Effectiveness and Permanence

Alternative SED-1 would not provide any long-term benefit, as any potential risk associated with impacted sediment is not eliminated through remedial action. The risk posed by the COPCs in sediment remains the same under Alternative SED-1.

Although there is no reduction in volume or toxicity of the contaminated sediment, Alternative SED-2 still provides a moderate level of permanence and effectiveness over the long term. Since no sediment is treated, the toxicity of the material remains the same, however accessibility and exposure to humans and biota is eliminated through containment.

Alternative SED-3 provides a high level of long term effectiveness and permanence for that sediment which is removed and treated. For the contaminated sediment that is capped there is no destruction of COPCs, but these materials are permanently contained and inaccessible to humans or biota, thereby reducing risk. A volume of approximately 78,000 cy would be permanently removed from the environment. If the sediment that is removed is not treated but disposed in a NR 500 landfill exposure to humans and biota is eliminated through access restrictions.

Alternative SED-4 would provide the highest effectiveness and permanence over the long term due to the permanent removal of the largest volume of sediment. If treated, thermal treatment of the sediment would eliminate toxicity and reduce volume and is permanent. If the sediment that is removed is not treated but disposed in a NR500 landfill exposure to humans and biota is eliminated through access restrictions.

4.5.4 Reduction of Toxicity, Mobility, and Volume through Treatment

Alternative SED-1 offers no reduction in toxicity, mobility, or volume through treatment, as no action is taken.

Alternative SED-2 would permanently reduce the mobility of contaminated sediments, and although the toxicity and volume would not change. While there is no destruction of COPCs, these materials are permanently contained and inaccessible to humans or biota, thereby reducing risk.

Alternative SED-3 would reduce toxicity, mobility and volume of a volume of approximately 78,000 cy of sediment which would be permanently removed from the environment. That sediment remaining under the cap would have permanently reduced mobility and since it would be inaccessible to humans or biota, it would eliminate exposure and risk. The inherent toxicity of that sediment remaining under the cap would not be reduced.

Alternative SED-4 would have the greatest degree of reduction of toxicity, mobility, and volume of impacted material. Mobility would be reduced by permanently containing it in a landfill. Likewise, toxicity would be reduced since exposure to humans and biota would be eliminated because access in a landfill is controlled.

4.5.5 Short-term Effectiveness

Alternative SED-1 would have the least short-term impact on human health and the environment, as impacted sediment would not be disturbed, thereby potentially releasing COPCs into surface water and air. Of the three active remedial options, Alternative SED-2 would have the least short-term impact, as sediment is not brought to shore for dewatering or treatment, but is disposed as part of the CDF, a portion of which is subaqueous. Adequate controls would be in place to ensure worker and community safety during remedial activities. All alternatives would have the potential of some short term risk from release of volatile emissions during debris removal and onshore dewatering and/or treatment. Release of volatile emissions from land-based activities including filling of a CDF could be better controlled than for dredging activities.

4.5.6 Implementability

Implementation of Alternative SED-1 would be easy, as no action would be performed. In addition, because no remedial action would occur, there would be no difficulty in implementing additional remedial actions at a later date.

Alternative SED-2 would be more difficult to implement than Alternative SED-1. The technology and equipment that would be used for this alternative is readily available, and has proven to be reliable at other similar sites. However, because WDNR has indicated that the governor and legislature must approve Alternatives SED-2 and SED-3, obtaining authorization to proceed may be problematic. Long term monitoring, included as a part of Alternatives SED-2, SED-3, and SED-4, would allow periodic evaluation of risks associated with materials left in place.

Alternatives SED-3 and SED-4 would be still more difficult to implement, as additional equipment, technology, and permitting would be required to perform the dewatering, thermal treatment, and disposal of sediment. Furthermore, the capping component included as part of Alternative SED-3 would add additional complexity to the implementation of this alternative.

4.5.7 Cost

Alternatives SED-1 would be the lowest cost alternative.

The cost for Alternative SED-2 would be greater than costs for Alternative SED-1, but less than either of Alternatives SED-3 or 4 (Table 4-9). It is anticipated that the cost for implementation of Alternative SED-2 would be approximately $29,000,000. Costs for Alternative SED-3 would be greater than Alternative SED-2, but less than Alternative SED-4. They would range from approximately $38,000,000 to $59,000,000. Cost for implementation of Alternative SED-4 would range between approximately $42,000,000 and $85,000,000

5.0 Summary and Conclusions

5.1 Soil

Based on this evaluation, unlimited removal and off site disposal **(*Alternative S3B*)** will provide the most long-term benefit with minimal short-term implementation issues. However, this benefit is outweighed by the costs and impacts associated with Restoration, which may include backfilling with clean fill to pre-excavation grade, or restoration as a wetland or shallow lakebed (i.e. pre-filling conditions). Limited removal and off site disposal (***Alternative S3A***), limited removal and on site disposal (***Alternative S4***), limited removal and thermal treatment (***Alternative S5A***), and limited removal and off site incineration (***Alternative S5A***) will provide long-term benefits with the minimal short-term implementation issues. A pilot test will be needed to further evaluate the feasibility of limited removal and on site soils washing (***Alternative S6***). Regardless, all potential remedial alternatives requiring limited removal are more cost effective than the unlimited removal alternative. Containment using engineered surface barriers (***Alternative S2)***) is a low cost response that would be easy to implement, but would need to be completed with a groundwater remedial response to be effective. Limited removal alternatives will result in the reduction in a significant mass of VOC, PAH, and NAPL contamination, but may need to be completed with other potential remedial alternatives for groundwater to provide maximum protection of human health and the environment. The no action alternative (***Alternative S1***) while costing little to nothing, will not provide any long-term protection, and should not be considered.

5.2 Groundwater

Groundwater remedial alternatives evaluated in this report include no action, containment, in-situ treatment, and removal technologies identified in the Alternative Screening Technical Memorandum (URS, revised May 2007). No Action (***Alternative GW1***) was also retained as required by the NCP as a basis for comparing the other alternatives. Containment alternatives include ***Alternatives GW2*** (containment using surface and vertical barriers) and ***Alternatives GW-5 (***in-situ treatment using PRB walls). If implemented, ***Alternatives GW5*** would be used with ***Alternatives GW2*** to minimize long-term treatment of shallow groundwater. The remaining in-situ treatment alternatives include the following:

- ***Alternative GW3*** - In-situ Treatment using Ozone Sparging;
- ***Alternative GW4-*** In-situ Treatment using Surfactant Injection and Removal using Dual Phase Recovery;
- ***Alternative GW6 -*** In-situ Treatment using Chemical Oxidation;
- ***Alternative GW7 -*** In-situ Treatment using Electrical Resistance Heating; and,

- ***Alternative GW8 -*** In-situ Treatment using Dynamic Underground Stripping /Steam Injection.

Removal technologies evaluated for groundwater include dual phase recovery and removal using extraction wells. Dual phase recovery was evaluated with ***Alternative GW4*** (in-situ treatment using surfactant injection) and removal using groundwater extraction wells (***Alternative GW9)*** was evaluated as a stand alone remedial technology. However, all in-situ remedial technologies evaluated may require groundwater extraction is some capacity.

Containment is not a feasible remedial alternative for the underlying Copper Falls aquifer. The remaining groundwater remedial alternatives could be used for shallow groundwater in the upper area and Kreher Park and for the Copper Falls aquifer. Buried structures in the upper bluff area and the wood waste layer in Kreher Park may limit the effectiveness of in-situ treatment in these areas. If removal and disposal (on- or off site) or on site treatment is selected as a remedial response for soil, or if containment is selected for shallow groundwater, in-situ treatment and or removal will not be necessary for soil and shallow groundwater contamination. However, one or more of the in-situ or removal technologies evaluated in this report will be required for the Copper Falls aquifer.

5.3 Sediment

For sediment, Alternative SED-2 would provide the most long-term benefit with the lowest cost and fewest short-term implementation issues. However there would be permanent loss of approximately 6 acres of shallow lake bed habitat. WDNR has also indicated that the Governor and Legislature would have to approve this alternative, thus making administrative implementability more problematic.

Alternative SED-3 would provide a slightly higher level of performance only because under Alternative SED-3 approximately 78,000 cy would be removed from the environment and either treated or disposed in a NR500 landfill. However Alternative SED-3 would have a greater cost than Alternative SED-2 and arguably a subaqueous cap has the potential of being less permanent than a CDF. In addition the requirement for more debris removal and for sediment treatment increases the short term risk of implementation of this alternative due to the likelihood that these activities would result in release of potentially harmful volatile emissions. As with Alternative SED-2, WDNR has indicated that the Governor and Legislature would have to approve this alternative, thus making administrative implementability more problematic.

Alternative SED-4 would offer the greatest protection of human health and the environment, but at a cost that is almost 50% greater than Alternative SED-2 ($42,,000,000 versus $30,500,000). If all dredging is conducted mechanically and there is no need for thermal treatment Alternative SED-4 is approximately the same cost as Alternative SED-3 ($42,000,000 versus $38,000,000). However if hydraulic dredging is required and there is a need to thermally treat the sediments the cost for Alternative SED-4 could be as much as 50% greater than Alternative SED-3

($85,500,000 versus $59,000,000) In addition the requirement for substantially greater debris removal and for treatment of almost twice as much sediment as Alternative SED-3 results in this alternative having the greatest short term risk of implementation due to the likelihood that these activities would result in release of potentially harmful volatile emissions. Unlike Alternatives SED-2 and SED-3, Alternative SED-4 does not have to be approved by the Governor and Legislature.

Alternative SED-1, while costing little to nothing, would not provide any long-term protection, and therefore should not be considered.

Based on this evaluation, Alternative SED-2 would provide the most long-term benefit at the least cost and with the fewest short-term technical implementation issues. Although WDNR has indicated that it will require approval by the Governor and Legislature the effort to acquire this approval would be compensated for by:

1) Substantially less costs that have to be borne by Xcel Energy rate payers;
2) The least potential risk to the Ashland community; and
3) Creation of a waterfront park that would benefit the Ashland economy by enhancing recreational opportunities.

6.0 References

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FIGURES